# High-power low-noise 1550nm DFB semiconductor lasers


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**Abstract:** We have designed and fabricated 1550nm DFB semiconductor lasers with output power 200 mW, SMSR > 60dB and the relative intensity noise < -165 dB/Hz in 0.5 to 18 GHz frequency range.



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High power and low noise 1550 nm semiconductor lasers are important for RF photonic links. Due to the effect of laser relaxation-oscillations on the relative intensity noise (RIN), there is RIN peak at the laser relaxation-oscillation frequency [1], which limits the applications of the lasers. To reduce the RIN magnitude or push the RIN peak to high frequency, many authors have reported various approaches [1 to 3]. However, to our knowledge, there has been no reported demonstration of 1550 nm DFB semiconductor laser with output 200 mW, and RIN below -165 dB/Hz in the frequency range 0.5 – 18 GHz.

We have designed and fabricated 1550 nm DFB semiconductor lasers that exceed published results. Our test results show laser output power 200 mW, side-mode suppression ratio (SMSR) over 60 dB, and the RIN is lower than -165 dB/Hz in 0.1 to 20 GHz. In this paper, we present our measurements and test results.

To fabricate lasers with low threshold current, high efficiency, and high output power, it is very important to optimize the wafer quantum wells, laser grating and cavity structure, fabrication process and laser to submount bonding. We have fabricated lasers with Planar Buried-Ridge-Structure (PBRS) and Buried Hetero-structure (BH). In this paper we report results from the BH structure. This kind of laser structure provides better current confinement in horizontal direction, which is important to make high efficiency, high power, and low threshold current lasers. To obtain the required laser output power of 200 mW, the laser cavity length is in the range from 1.5 mm to 2.4 mm. The grating is fabricated in a 1.05 Q InGaAsP layer above the active layers, with optimal grating coupling coefficient. Both laser facets were coated, one facet with high-reflectivity coating (HR) reflectivity~ 97%, and the other with anti-reflection coating (AR) reflectivity ~0.01%.

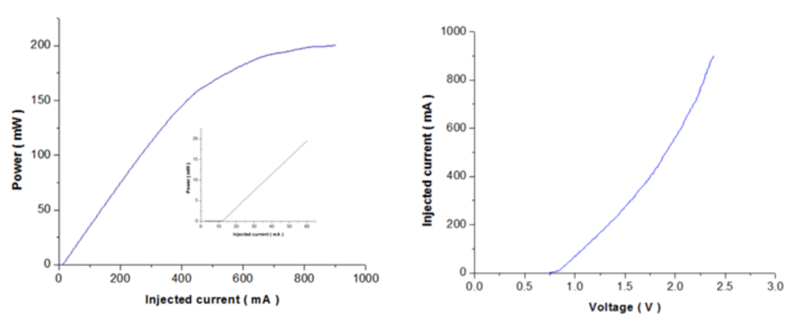


Figure 1. (a) laser P-I, and (b) I-V characteristics.

The lasers were bonded P-side down onto AlN submounts. The submounts were mounted onto a copper heatsink with thermal stabilization by a thermo-electric cooler.

Figure 1 (a) and (b) show the P-I and I-V characteristics of a laser with cavity length 1.8 mm. The maximum power 200 mW was obtained at the laser bias of 960 mA. The insert in the figure 1 (a) depicts the laser P-I bias near threshold showing threshold current of 11 mA and slope efficiency of 0.4 mW/mA. Figure 2 displays typical laser spectrum with SMSR ove 60 dB.

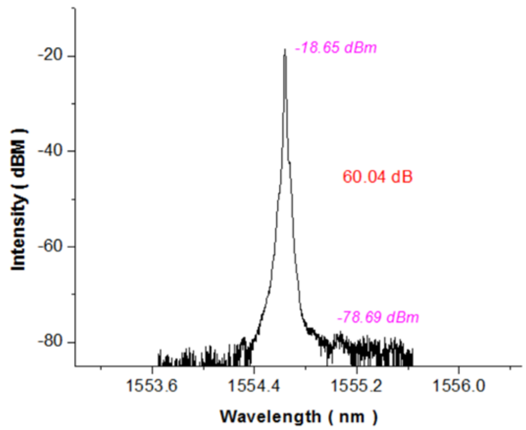


Figure 2. Typical laser spectrum.

We used Agilent 71400C and 71401C lightwave signal analyzers to measure the laser RIN. Figure 3 demonstrates the laser RIN spectra at different biases (a) 14 mA, (b) 40 mA, (c) 100 mA, and (d) 300 mA.

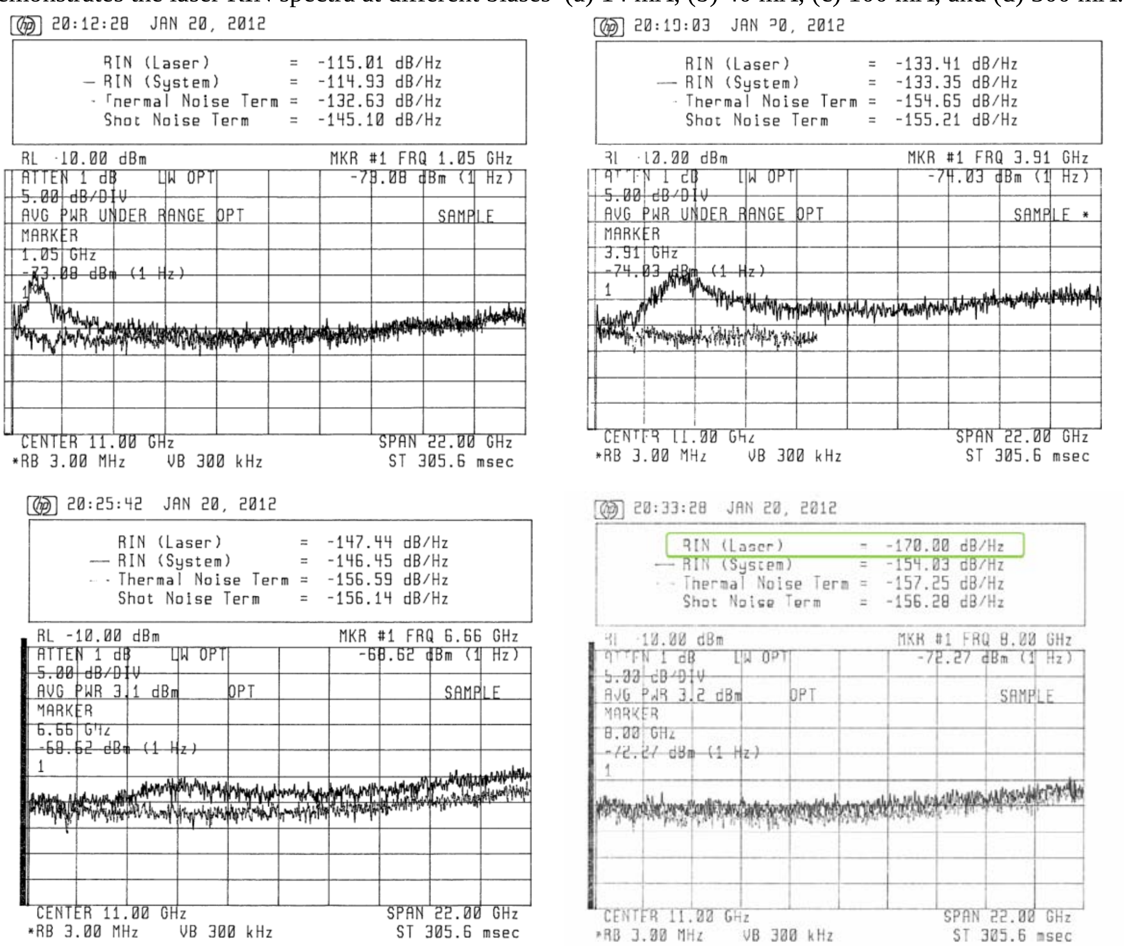


Figure 3. RIN spectra at different laser biases ( a ) 14 mA, (b) 40 mA, (c) 100 mA, and (d) 300 mA.

There are two different curves in each plot. The upper is with the laser on measuring total RIN, and the lower curve is with laser off to calculate thermal noise and shot noise of the system. As the laser bias is increased the RIN peak value decreases, and moves to high frequency. Table 1 is a list of the laser bias dependence of the RIN peak frequency and the RIN value at the peak. Above the laser bias of 300 mA, the laser RIN is lower than the shot noise.

Table 1. List of the laser bias dependence of RIN peak frequency and RIN value

| Laser bias (mA) | 14 | 40 | 100 | 300 |
|---|---|---|---|---|
| RIN peak frequency ( GHz) | 1.05 | 3.91 | 6.66 | None |
| RIN peak value (dB/Hz) | -115.01 | -133.41 | -147.44 | -170 at 8 GHz |

These results are in very good correlation our laser modeling and simulations [4].

Figure 4 shows detailed frequency measurement of laser RIN for 100 mA and 400 mA. The Agilent system RIN measurement limits are -170 dB/Hz and 20 GHz. We believe our lasers can reach < 170 dB/Hz RIN operation.

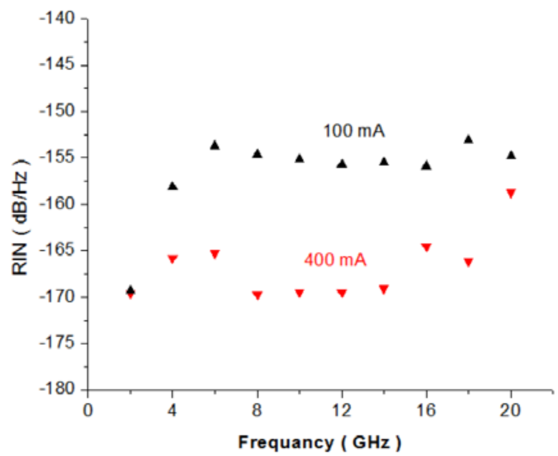


Figure 4. Laser RIN spectrum at different biases 100 mA and 400 mA.

We have designed and fabricated 1550 nm DFB semiconductor lasers. Our test results show that the lasers have the highest reported performance. We measure laser output power of 200 mW, RIN lower than -165 dB/Hz in the frequency range of 0.l to 20 GHz, and SMSR is over 60 dB.

**Acknowledgement**

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