

High-speed direct modulation of 1.3 μm InAs quantum dot laser grown on on-axis (001) Si substrate

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Quantum dot (QD) lasers have enormous potential for on-chip silicon light sources [1]. Low threshold and reliable operation of InAs QD lasers monolithically grown on an on-axis (001) Si substrate have been demonstrated [2]. Though direct modulation of QD laser on Si has been performed for bonded integration platform, there has been no report on direct-modulation properties of QD lasers epitaxially grown on Si. [3]. Here, we report the first demonstration of a direct-modulation of QD laser grown on Si. As a result, 12.5 Gbit/s direct modulation was successfully achieved.

Figure 1 shows the epitaxial structure of the QD laser. A (001) Si substrate with a 45-nm-thick GaP buffer layer was used as an initial wafer. The dislocation filter layers, *n*-GaAs buffer layer and the laser structure with five-layer QD active region with a dot density of $4.9 \times 10^{10} \text{ cm}^{-2}$ and *p*-doped ($N_A = 5 \times 10^{17} \text{ cm}^{-3}$) GaAs barriers were grown by solid-source molecular beam epitaxy (MBE). A ridge-waveguide structure was processed using standard lithography and dry etching techniques. The processed wafer was cleaved to form a Fabry-Perot cavity. A high reflection coating (99% reflection) was deposited on one side of the facets. The measured device has a cavity length of 580 μm and a mesa stripe width of 5 μm . The threshold current is 14 mA at room-temperature.

Figure 2 shows small-signal responses for various bias current conditions measured by a lightwave component analyzer. The 3dB bandwidth is 6.5 GHz at a bias current of 116 mA. The *K*-factor extracted from the small-signal responses is 0.92 ns, which corresponds to a maximum 3dB bandwidth of 9.6 GHz. Figure 3 shows bit-error-rate (BER) characteristics for non-return-to-zero (NRZ), PRBS = $2^{31}-1$ signal. The minimum receivable powers are -3.4 dBm, -9.5 dBm and -12.5 dBm for the data-rate of 12.5 Gbit/s, 10 Gbit/s and 7.5 Gbit/s, respectively. These curves show no error-floor up to BER of 1×10^{-13} . The inset of Figure 3 shows 12.5 Gbit/s eye diagram at a bias current of 100 mA. The extinction ratio was 3.3 dB at this data rate.

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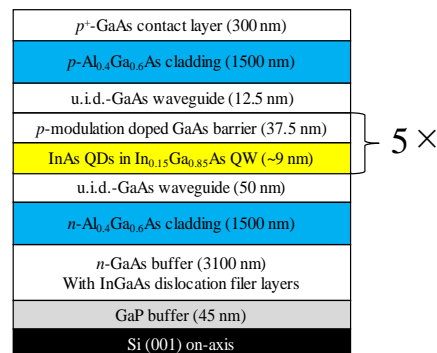


Fig. 1 Epitaxial structure of the InAs QD laser grown on a (001) Si substrate.

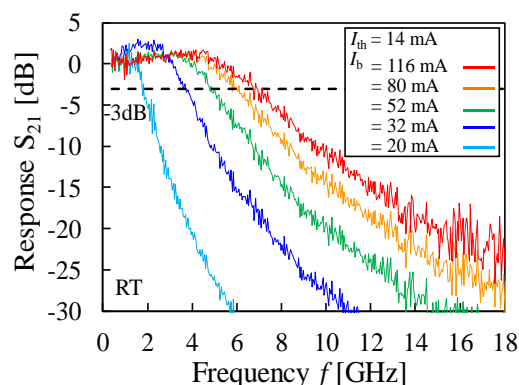


Fig. 2 Small-signal responses for various bias current conditions.

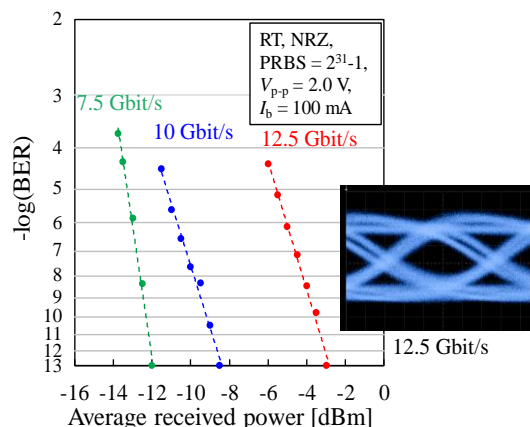


Fig. 3 Bit-error-rate characteristics and 12.5 Gbit/s eye diagram.

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References

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