96 GHz Colliding Pulse Mode-locked Quantum Dot Lasers Grown on Silicon

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Needed increases in internet bandwidth require developing chip-scale photonic interconnects to displace electronics. The silicon photonics platform is favorable for photonic integration due to silicon's mature manufacturing techniques and large substrates. In recent years, quantum dot (QD) lasers have proven themselves as ideal candidates for epitaxial integration with the silicon photonics platform due to their defect tolerance which results in low threshold currents and long device lifetime [1,2]. Here, we report the first QD colliding pulse mode-locked lasers (MLLs) grown on Si. The tunable gain bandwidth and ultrafast recovery of QDs makes them ideal for MLLs with narrow, high repetition rate pulses and wide bandwidth frequency combs for dense wavelength division multiplexed data transmission.

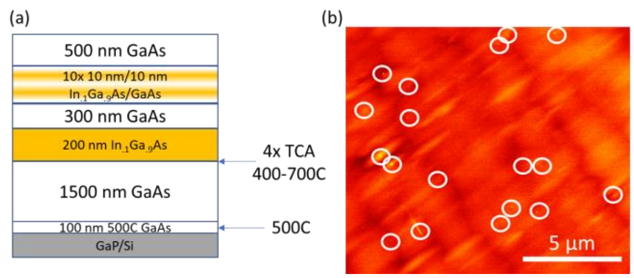

Figure 1(a) Buffer schematic. (b) Electron channeling contrast image with threading dislocations indicated.

Samples were grown on a defect free, pseudomorphic 45 nm GaP on Si template from NAsP$_{III/V}$, GmbH. An optimized buffer (Fig. 1(a)) consisting of a low temperature GaAs nucleation layer, thermal cycling, and InGaAs filter layers was utilized to achieve a dislocation density of 6×10^{7} cm^{-2} (Fig. 1(b)). Quantum dot lasers were then grown with AlGaAs cladding and five periods of p-modulation doped InAs QDs in InGaAs quantum wells. The QDs were grown at 485°C and V/III ratio of 35 with nominal InAs deposition of 2.55 ML. These conditions yield dot densities ~6×10^{10} cm^{-2} and photoluminescence full-width at half-maximum of 30 meV. Standard dry etching and metal deposition techniques were used to fabricate the lasers. Mode-locking was observed with 96 GHz repetition frequency and 2 ps pulsewidth. The continuous wave light output curve, mode-locked optical spectrum, and corresponding autocorrelation trace are shown in Fig. 2.

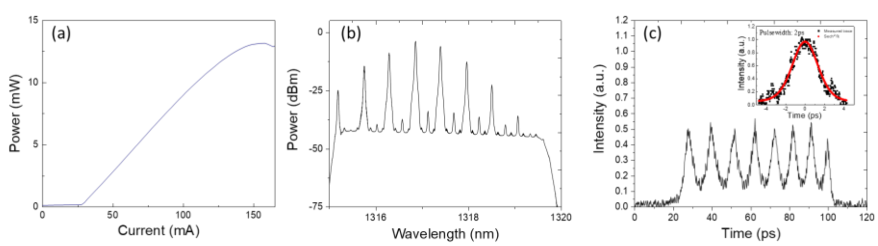

Figure 2(a) Light output vs current. (b) Colliding pulse MLL optical spectrum. (c) Autocorrelation trace with Sech^2 pulse fit (inset) (I_{gain} = 134 mA, V_{SA} = - 4.4 V)

[1] D. Jung, et al., ACS Photon. **5**, 1094-1100 (2018).
[2] D. Jung, et al., Appl. Phys. Lett. **112**, 153507 (2018).

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