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High-speed Direct Modulation on III-V-on-SOI Distributed Feedback lasers with intrinsic electro-optical bandwidth over 20 GHz

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Heterogeneous integration of III-V materials on silicon photonics circuits has emerged as an attractive approach to demonstrate compact lasers that address a wide range of applications ranging from short distance data communication to long distance optical transmission. Directly modulated III-V-on-SOI lasers (DML) with high bandwidths such as distributed feedback (DFB) lasers are particularly well suited for those applications that require high optical power and stable single-mode performance [1].

Research on high-speed DMLs is progressing steadily, with a few benchmarking results published up to date. For instance, an integrated DFB laser that can be modulated at 28 Gb/s with a 3 dB modulation bandwidth of 15 GHz has been demonstrated in ref. [2]. To improve the electro-optical (EO) response, DMLs have also been associated with external optical cavities to benefit from the photon-photon resonance (PPR) to extend the modulation bandwidth. A representative example can be found in ref. [3], where a 3 dB bandwidth of 60 GHz was demonstrated using a membrane III-V on SiO₂/Si DML combined with an external cavity to exploit the PPR effect. In any case, having a high intrinsic EO response (without any external cavity) is always beneficial to improve the dynamic performance. In our previous work on DMLs, we demonstrated a directly modulated backside sampled Bragg grating laser with a cavity length of 885 μm and a modulation bandwidth of 14 GHz at 3 dB [4]. This allowed us to do the non-return-to-zero (NRZ) modulation at 25 Gb/s and transmission over a 2 km optical fiber.

In this paper, we present our recent work on high-speed III-V-on-SOI DFB lasers with backside Bragg gratings. We have achieved an intrinsic 3 dB modulation bandwidth above 20 GHz in the C-band and we demonstrate 32 Gb/s pseudo-random bit sequence NRZ direct modulation. Such a laser combines a low-loss Si rib waveguide with an III-V PIN waveguide based on AlGaInAs multi-quantum wells. Both waveguides are vertically aligned and separated by a thin bonding oxide (25 nm), as can be observed in Fig. 1(a). The laser has a cavity length of 400 μm, the grating being etched at the backside of the Si guide (in the slab) at an etching depth of 30 nm, and presents a λ/4-shifted with a grating pitch of 240 nm.

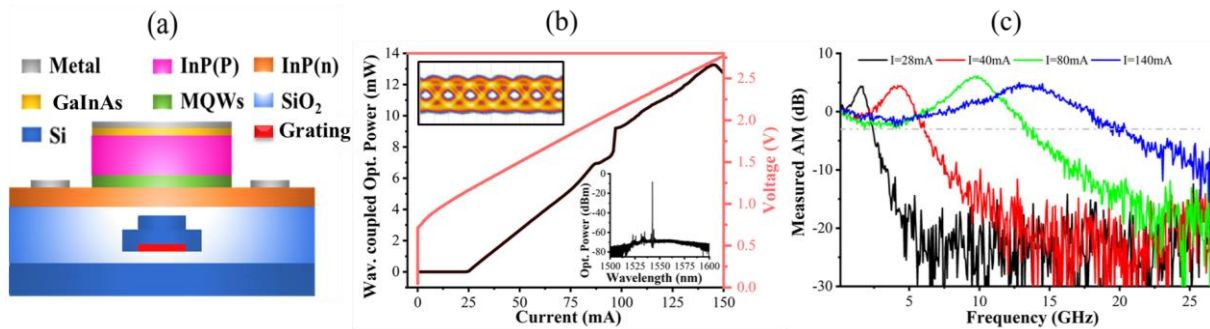


Fig. 1 (a) Schematic cross section (b) L-I-V characteristic (c) Room temperature frequency response for different bias currents

The static L-I-V characteristics at room temperature condition are shown in Fig.1 (b). The measured threshold current is 26 mA. The optical power coupled in the waveguide obtained from a single facet is above 11 mW. Embedded in the same figure, the optical spectrum shows us that we have a single-mode laser with a side mode suppression ratio (SMSR) greater than 50 dB. The small-signal modulation response for different bias currents of the DFB laser was evaluated and is shown in Figure 1(c). Thanks to the design of our component, we can bias our single-mode laser at high currents, which increases the bandwidth. At 140mA of bias current, the device's modulation bandwidth is estimated to be around 21 GHz.

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