High-Power III-V-on-Silicon Semiconductor Optical Amplifier (> 50 mW) for Integrated Mode-Locked Lasers

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Integrated semiconductor optical amplifiers (SOAs) with high output power are essential components in many future photonic applications such as LIDAR, microwave photonics and coherent optical communication [1]. Even more so in integrated mode-locked lasers, where the amplifier can severely limit the pulse energy [2]. InP/InGaAsP SOAs with high optical confinement can suffer from two-photon absorption and non-linear absorption associated with the generated carriers.

In this work we report a SOA integrated on a silicon waveguide circuit with a small-signal gain of 27 dB, CW output power exceeding 17 dBm and reduced confinement in the III-V (See Fig. 1). This is, to the best of our knowledge, the III-V-on-silicon SOA with the highest output power. This is achieved by including a thick (400 nm) and wide (4 μm) silicon waveguide underneath the III-V gain waveguide (See Fig. 1(b) and 1(d)). A schematic top view of the amplifier is shown in Fig. 1(e).

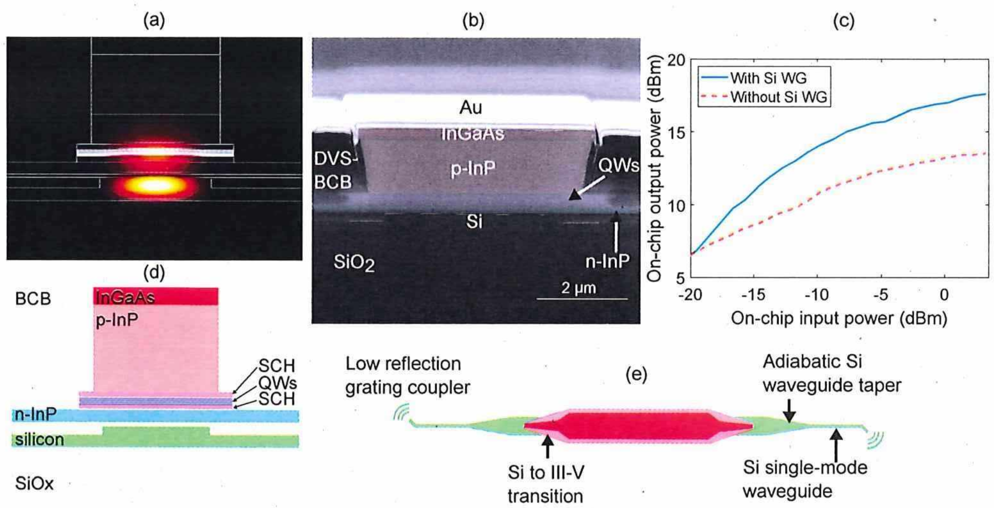

Fig. 1 (a) Simulated hybrid mode in the SOA; (b) Colorized SEM image of the gain waveguide cross-section; (c) On-chip output power of high-power SOA and SOA without Si waveguide underneath; (d) Schematic layer stack of the gain waveguide; (e) Schematic lay-out of the amplifier.

We have previously demonstrated a high-performance III-V-on-silicon mode-locked laser with a 1 GHz repetition rate, 250 kHz optical linewidth and a 10 nm wide optical spectrum [3]. However, the optical amplifier was not optimized for high-output power. To demonstrate the advantage of using low optical confinement in the III-V we compare the output power of a SOA with and without silicon waveguide underneath (See Fig. 1(c)). The SOA without silicon waveguide underneath has a small-signal gain of 29 dB but provides a maximum of 13.5 dBm output power. The high-power SOA with wide waveguide underneath has a small-signal gain of 27 dB but delivers up to 17.5 dBm of optical output power for an input power of 3.5 dBm (see Fig. 1(c)). At the conference we will present further comparison results between both SOAs types. Furthermore, a cut-back measurement was performed to determine the internal loss of the gain waveguide and the III-V-on-silicon transitions. Finally, we investigated the amplification of short pulses, both in the SOA with and without silicon waveguide underneath.

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Abstract

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