GaSb - Photonics Integrated Circuit Lasers at 1.9 – 2.7 µm Wavelength Band for Sensing Applications

J. Viheriälä, Samu-Pekka Ojanen, Nouman Zia, H. Tuorila, Joonas Hilska, Eero Koivusalo and M. Guina

Natural Science and Engineering, Tampere University, 33720, Tampere, Finland

Spectroscopic sensors working around 1.9 – 2.7 µm wavelength are particularly useful due to the strong molecular absorption of several important gases (for example CO_2, CH_4, CO, N_2O) and biomolecules (for example glucose, urea, lactate). Integrated photonics provides means to tackle more and more of these applications as its able to miniaturize sensors and to large extent parallelize their assembly making them more affordable to ease their deployment to new applications. This is because photonics integrated circuits (PICs) work as an integration platform to combine spectrally selective components, light sources, detectors, and other functional elements on a single chip [1]. One of the challenges with PICs is in the realization of on-chip mid-IR light sources since the PIC waveguide materials does not allow efficient light emission at mid-IR. To solve this limitation, we have explored both Si_3N_4 and Silicon-on-Insulator (SOI) waveguide technology toward integration with GaSb-gain chips and light emitters to realize the hybrid lasers at 1.9 - 2.7 µm. In particular, two hybrid laser configurations based on 1) distributed Brag grating (DBR) on SOI and 2) ring resonator-based cavity on Si_3N_4 are presented for the wavelength selection and tuning. We present state-of-the-art results in terms of the device performance and the integration between GaSb and PICs. We alsodiscuss the limitations in wavelength scaling beyond 3 µm and give an outlook towards integrated sensors.

In first configuration, we show to our knowledge the first on-PIC integrated GaSb hybrid laser. The laser operates at 1.985 µm emission wavelength and consists of a flip-chip integrated GaSb chip coupled with an SOI-waveguide having a DBR grating forming laser cavity exhibiting a narrow emission spectrum (Fig 1a). The wavelength of this laser can be tuned with a heater integrated on DBR-grating. The laser allows output power levels up 6.5 mW in CW at room temperature (RT) and tunability of a few nanometers. Integration approaches gives potential to integrate many of these lasers at different wavelengths side-to-side towards the emission of multiple discrete wavelengths. The second laser is based Si_3N_4-waveguide circuit allowing a widely tunable reflection spectrum. In this laser, the GaSb-gain chip is edge coupled with PIC to form a cavity. The realized laser allows to address wavelengths from 2475 nm to 2655 nm (170 nm range, Fig 1b) with output powers ranging from 2 mW to 5.5 mW, in CW at RT, depending on operation wavelength. The wide tunability of the laser cavity allows addressing of multiple wavelengths over a continuous range.

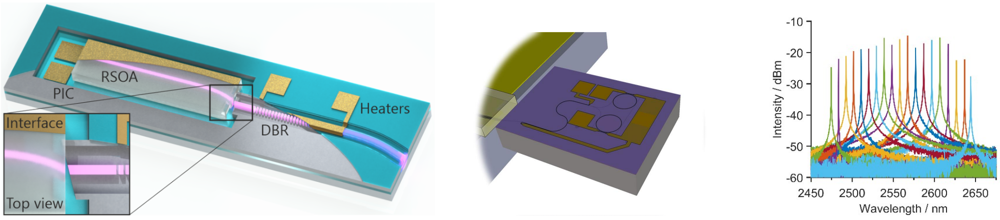

Fig. 1. Left panel: On-chip integration scheme based on flip-chip bonding and butt-coupling gain chip waveguide with SOI-waveguide and DBR-grating. Center: integration of Si_3N_4-GaSb laser. Right panel. Wide tunable emission spectrum of Si_3N_4-GaSb laser.

[1] Thomson, David, et al. "Roadmap on silicon photonics." Journal of Optics 18.7 (2016)