

GaSb-based integrated lasers and photodetectors on a Silicon-On-Insulator waveguide circuit for sensing applications in the shortwave infrared

N. Hattasan^{1*}, A. Gassenq¹, L. Cerutti², J.B. Rodriguez², E. Tournié², G. Roelkens¹

¹Photonics Research Group-UGent/imec, Sint-Pietersnieuwstraat 41, 9000 Gent, Belgium

²Université Montpellier 2 – CNRS, UMR 5214, Place Bataillon, 34095 Montpellier, France

The interest in sensing liquids and gases such as CH₄ and CO in the shortwave infrared has increased over the past decade due to the low water absorption in this region. Conventional spectroscopic techniques, which may offer high accuracy, require expensive and bulky sources and detectors. However, a compact, low-power system is strongly desirable for many applications.

GaSb and its compounds are an excellent semiconductor material for the shortwave infrared. Several room temperature operating lasers and detectors have thus far been demonstrated using GaSb, making it suitable for integrated active components [1]. Silicon-On-Insulator (SOI), on the other hand, offers mass production of optical circuits with CMOS compatibility. This makes it ideal as a passive integrated optical circuit platform. Combining SOI and GaSb optoelectronic components could thus yield a compact, efficient spectroscopic detection system.

Here, we report integrated InGaAsSb (grown lattice-matched on a GaSb substrate) photodetectors on SOI and integrated Fabry-Perot (FP) lasers. The epitaxial layers are transferred onto the Si waveguide circuit by a die-to-wafer bonding process using Benzocyclobutene (BCB) as the bonding agent. The substrate is completely removed before device processing. For photodetectors, we study two light coupling techniques from the SOI waveguide circuit to the integrated photodetector: evanescent coupling and grating-assisted coupling. High responsivity ($>1\text{A/W}$) of the evanescent photodiode and 0.4 A/W for grating-assisted coupling at $2.2\mu\text{m}$ is achieved. The dark current is $\sim 4\mu\text{A}$ at -1V . SEM images of both designs are shown in Fig.1a and 1b.

We also demonstrate thin-film GaSb-based FP lasers integrated on a carrier substrate. The $15\mu\text{m} \times 400\mu\text{m}$ device operates at $\sim 2.02\mu\text{m}$ wavelength in continuous wave at room temperature. A threshold current of $\sim 31\text{ mA}$ in pulse regime and 49.7 mA in continuous wave are achieved. The integrated laser operates up to 35°C . Figure 1c represents its spectrum at different bias current.

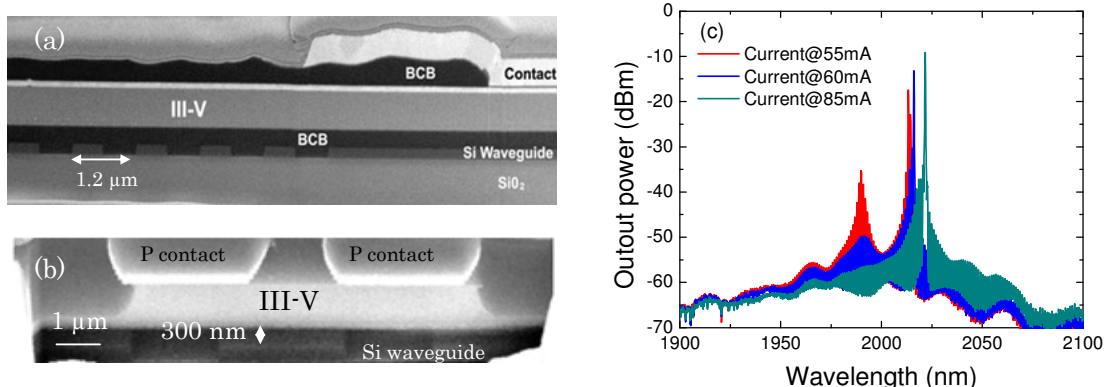


Fig.1 SEM image of the realized components (a) Grating-assisted coupling, (b) Evanescent coupling, (c) Spectrum at different bias current of the realized laser

[1] A. Bauer, K. Rößner, T. Lehnhardt, M. Kamp, S. Höfling, L. Worschech and A. Forchel, *Semicond. Sci. Technol.* **20**, 014032, 2011

* Corresponding author: email: nannicha.hattasan@intec.ugent.be

150 words:

We report integrated InGaAsSb (grown lattice-matched on a GaSb substrate) photodetectors on SOI and integrated Fabry-Perot (FP) lasers. The epitaxial layers are transferred onto the Si waveguide circuit by a die-to-wafer bonding process using Benzocyclobutene (BCB) as the bonding agent. The substrate is completely removed before device processing. For photodetectors, we study two light coupling techniques from the SOI waveguide circuit to the integrated photodetector: evanescent coupling and grating-assisted coupling. High responsivity ($>1\text{A/W}$) of the evanescent photodiode and 0.4 A/W for grating-assisted coupling at $2.2\mu\text{m}$ is achieved. The dark current is $\sim 4\mu\text{A}$ at -1V .

We also demonstrate thin-film GaSb-based FP lasers integrated on a carrier substrate. The $15\mu\text{m} \times 400\mu\text{m}$ device operates at $\sim 2.02\mu\text{m}$ wavelength in continuous wave at room temperature. A threshold current of $\sim 31\text{ mA}$ in pulse regime and 49.7 mA in continuous wave are achieved. The integrated laser operates up to 35°C .