Heterogeneous Integration of GaSb-based epitaxy on silicon-on-insulator: towards mid-infrared photonic integrated circuits for environmental and bio-medical applications

N. Hattasan[1*], L. Cerutti[2], J.B. Rodriguez[2], E. Tournié[2], D. Van Thourhout[1], G. Roelkens[1]

[1]*Photonics Research Group-UGent/IMEC, Sint-Pietersnieuwstraat 41, 9000 Gent, Belgium*

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

The interest in environmental and health care monitoring has increased significantly in recent years. This application typically requires the detection of substances which have characteristic absorption features in the mid-infrared wavelength region. Photonic integrated circuits can potentially be used to realize this functionality in a compact and low-cost fashion. This encourages the development of opto-electronic devices based on GaSb technology. Silicon-on-insulator (SOI) on the other hand is a very promising platform for passive optical functions, given the high omni-directional refractive index contrast of the so-called photonic wires, allowing for compact photonic integrated circuits, which can be fabricated using CMOS fabrication tools. The integration of GaSb active devices with SOI passive waveguide circuits would therefore allow for the realization of fully integrated mid-infrared photonic integrated circuits. This could accelerate the development of a number of applications in the environmental and medical field, such as spectroscopic gas sensors and implantable blood glucose sensors. In this paper we report on the heterogeneous integration of GaSb-based epitaxy on SOI waveguide circuits and show initial results on the realization of a GaSb-based photodetector integrated on SOI.

The heterogeneous integration is realized by epitaxial layer transfer through a die-to-wafer bonding process using the polymer DVS-BCB as a bonding agent. Before the bonding process, the GaSb epitaxy is cleaned with acetone and IPA. The SOI die is cleaned using a standard clean-1 solution ($NH_4OH:H_2O_2:H_2O$). The DVS-BCB polymer is diluted using mesitylene (to achieve a thin bonding layer) and then spin-coated on the SOI die. The sample is then baked on a hot plate at 150°C for 3 minutes. The bonding is performed at this temperature, after which the stack is cured at 250°C for 1 hour. After the bonding process, the GaSb substrate is removed using a combination of mechanical grinding and wet etching using a mixture of CrO_3 and HF until an InAsSb etch stop layer is reached. Figure 1 shows a SEM cross-section image of the GaSb layer transferred to an SOI waveguide circuit. A III-V/SOI separation of 150nm is easily achievable, which is sufficient for the optical coupling between the SOI waveguide circuit and GaSb-based opto-electronic components.

Based on such a heterogeneous GaSb-SOI layer stack, heterogeneous GaSb/SOI waveguide photodetectors were designed as a first step towards a mid-infrared photonic integrated circuit. In this device, depicted in figure 2, the mid-infrared light is evanescently coupled from the silicon waveguide layer to the GaSb absorption layer. Simulation results are shown in figure 3. At the conference, we will elaborate on the device performance.

---

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

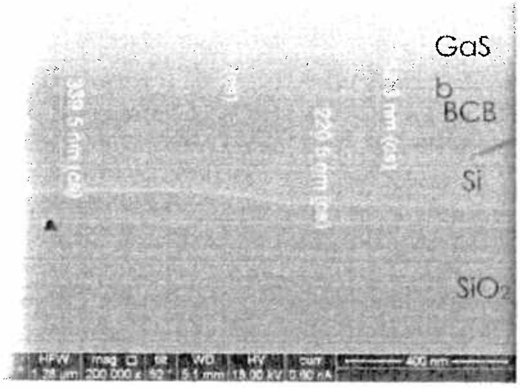


Figure 1: SEM cross-section image of the GaSb epitaxial layer stack (after GaSb substrate removal) transferred to a silicon-on-insulator waveguide circuit

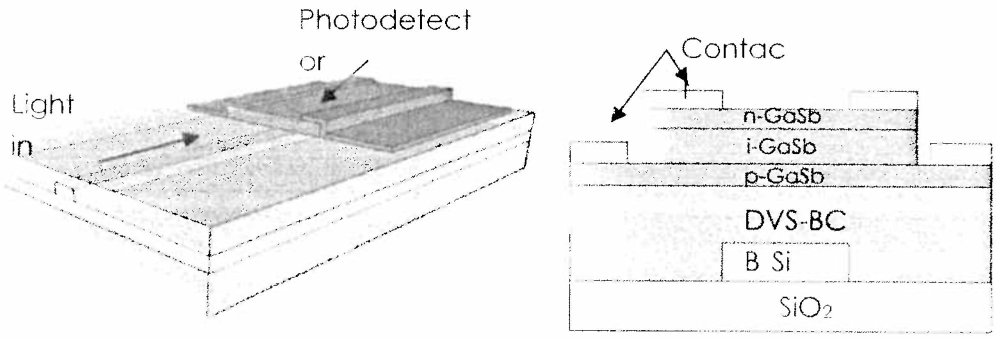


Figure 2: Photodiode device layout and schematic cross-section of the heterogeneous layer stack

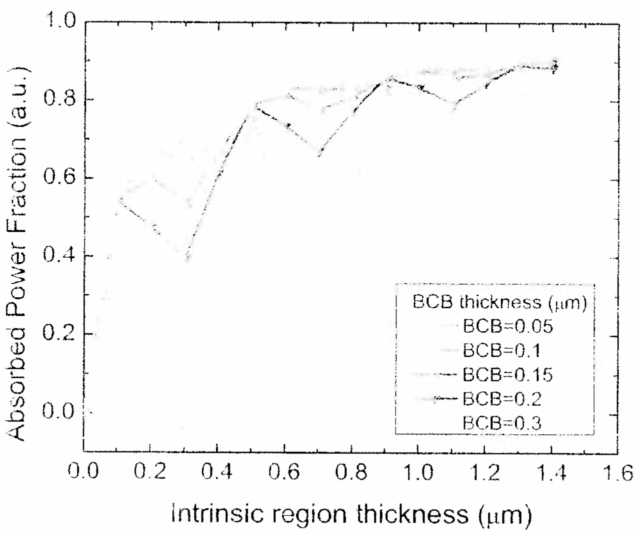


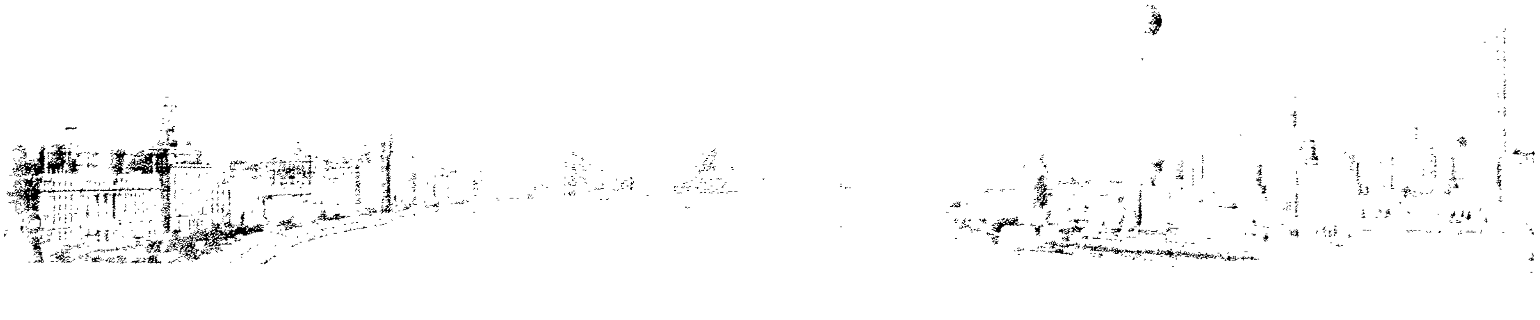
Figure 3: Absorbed power fraction as a function of the intrinsic region thickness and BCB layer thickness for a 20 μm long photodetector

10th International Conference on

Mid-Infrared Optoelectronics: Materials and Devices

September 5 – 9, 2010
Shanghai, China

PROGRAM AND ABSTRACTS



10th International Conference on

Mid-Infrared Optoelectronics: Materials and Devices (MIOMD-X)

September 5 – 9, 2010

Shanghai, China

Program and Abstracts

Organized by:

Shanghai Institute of Microsystem and Information Technology

Chinese Academy of Sciences

State Key Laboratory of Functional Materials for Informatics,China

865 Changning Road, Shanghai 200050, China

www.sim.ac.cn