Integrated butt-coupled membrane laser for Indium Phosphide on Silicon platform

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***Abstract* – In this work we present the design and technology development for an integrated butt-coupled membrane laser in the IMOS (Indium Phosphide Membrane On Silicon) platform** [1]**. Laser is expected to have a small footprint (less than 50 µm^2), 1 mA threshold current and a direct modulation frequency of 10 GHz.**

Keywords – Laser; PIC; IMOS; integration; butt-coupling; membrane; photonic crystal.

I. Introduction

Photonic integration on membranes can be used to combine electronic and optical functionality. InP membranes on Si is an advantageous solution, since it can include lasers, detectors and waveguide devices. An efficient laser is required for this platform [2]. Active-passive regrowth provides an optimized choice of laser materials and an easy coupling to waveguides. This paper reports the development of such an integrated laser.

II. Laser Design

Fig. 1a shows the schematic of the laser. It consists of an SOA structure with a cavity realized through mirrors in the waveguides. Electrical and optical confinement is provided by a double heterostructure with InGaAs as an active layer as shown in the cross-section in Fig. 1.b.

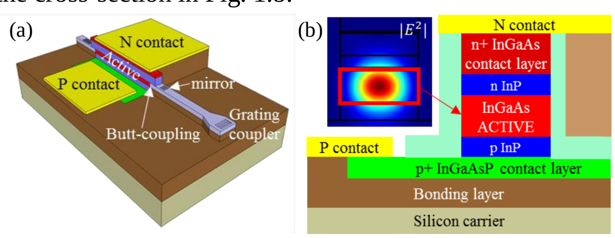

Fig. 1. (a)Schematic of the butt-coupled laser; (b) cross-section of a SOA.

To calculate laser parameters we perform gain calculations using the Poisson equation and Fermi's golden rule. Fig. 2. shows the calculated gain spectrum of the designed active layerstack with different injection current densities.

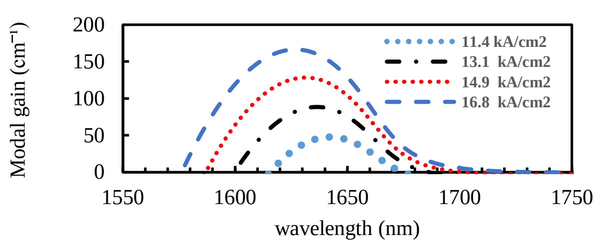

Fig. 2. Calculated gain spectrum of the SOA.

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Keeping the cavity loss below 100 cm^{-1} we can achieve threshold current density below 13 kA/cm^2. Choosing an appropriate geometry, according to calculations we can reduce the threshold current down to 1 mA in our platform. This gives above 10 GHz modulation frequency and up to 15 % wall-plug efficiency. FDTD results show that reflectivity of the surface DBR mirror is expected to reach up to 90 % and of a photonic crystal mirror up to 99 %.

III. Integration Technology Development

The thin InP membrane to be processed has topology on both sides. The first issue to solve is the active-passive regrowth which implies 2 MOCVD growth steps and 2 lithographies for markers and active islands definition. Regrowth has successfully been done for the IMOS platform [3]. The next challenge is to perform wafer bonding [4] without any pollution on the bonding layer requiring an extremely clean environment. After bonding we perform 3 lithographies for dry etching with ICP for structure definition, and 2 lift-off lithographies for metal contacts deposition. Special attention is given to reflector fabrication which is the most critical part of the whole process. We can implement 2 types of reflectors: DBR and photonic crystals. These are shown in Fig. 3.a and b respectively. The device is shown in Fig. 3. c.

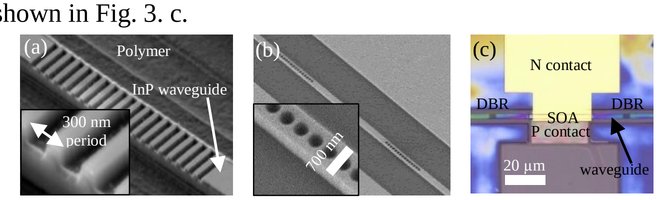

Fig. 3. (a) SEM picture of DBR; (b) SEM picture of photonic crystal reflectors; (c) photograph of the laser.

IV. Conclusion

An Integrated butt-coupled membrane laser is being developed for the IMOS platform. The laser is expected to operate above 10 GHz modulation frequency, have a 1 mA threshold current and has less than 50 µm^2 footprint. Realization in the IMOS platform is currently ongoing.

References

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