Towards efficient microdisk lasers heterogeneously integrated with SOI

Thijs Spuesens, Liu Liu, Dries Van Thourhout
Ghent University, Ghent, Belgium

In the last few years integrated optical networks gained much interest because of their large bandwidth, immunity to electromagnetic noise and the absence of frequency dependent loss or cross talk. Silicon-on-insulator (SOI) is an emerging platform to implement these Photonic Integrated Circuits (PICs). A very high integration density can be obtained, because of the high refractive index contrast. Another advantage is that it is possible to use the mature CMOS technology to fabricate these PICs at low cost and with high accuracy.

However, one of the major problems with SOI is the difficulty to achieve light emission and amplification, due to the indirect bandgap of silicon. An interesting approach is the heterogeneous integration of III-V material on a SOI substrate, where the light is generated in the III-V material and coupled into the silicon waveguide.

Recently microdisk lasers heterogeneously integrated on SOI have successfully been demonstrated. Microdisk cavities support optical resonances of the whispering gallery type, which have a very low radiation loss also in very small cavities. The resonant modes propagate at the edge of the disk without the need of a guiding structure, this way it is possible to put a metal contact at the top, in the center of the disk, without inducing optical losses. The efficiency of this approach however, is still poor.

We will focus on the design and fabrication of microdisk lasers with decreased power consumption and increased modulation speed. To increase the efficiency of the microdisk laser we will focus on the improvement of carrier injection efficiency, coupling from the microdisk laser to the waveguide and reducing the self heating of the microdisk laser. In the current microdisks the current is injected in the center of the disk, while the light is strongly confined at the edge of the disk. Thus, a significant part of the injected carriers do not contribute to the laser operation which results in a higher threshold current. Because of the thin structure of the disk it is not possible to put metal contacts on the edge of the disk since this will induce severe optical losses.

We propose to edge a hole in the center of the disk, this way the carriers will recombine closer the edge of the disk and effectively contribute to the laser operation. We will also study the possibility to optimize the epitaxial structure of the disk. By introducing a well designed current spreading layer the carriers are as much as possible guided to outside of the disk. However, a trade off has to be made between the optical confinement and carrier injection efficiency.

The light is coupled from the microdisk laser to the silicon waveguide by means of evanescent coupling. The efficiency of this coupling depends on several parameters like the positioning of the silicon waveguide compared to the disk, the thickness of the microdisk and the bonding layer. We will investigate the coupling efficiency through simulations with a FDTD tool and optimize the parameters involved. A possible solution to increase the coupling efficiency is to make use of bended waveguides that, to some extent, follow the shape of the microdisk. In general, the threshold current of a laser diode increases exponentially with temperature. Therefore, to get a high efficiency, it is important to have sufficient thermal conduction. This is difficult with the current microdisk laser design since the bonding material Benzocylcobutene (BCB) has a low thermal conductivity. We will investigate the possibility to include a heat sink in the design of the disk which is connected to the silicon substrate. A considerable increase in performance of the microdisk laser is expected from the above mentioned proposals.

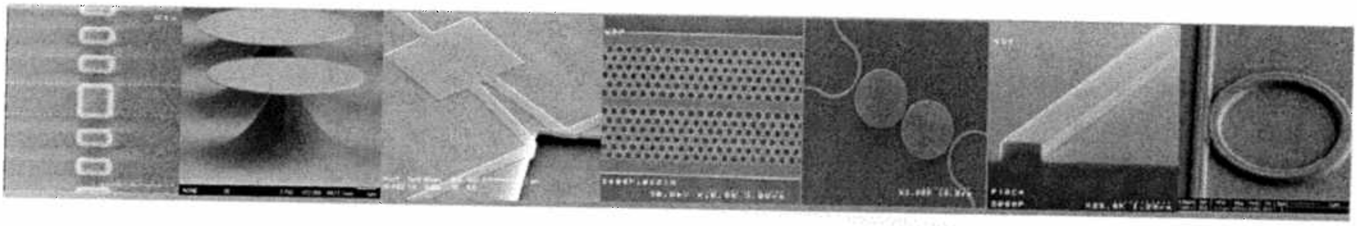
With these changes a threshold current of 150 uA and an output power of 100 uW should be within reach.

III-V lasers on silicon: devices and coupling schemes to silicon-on-insulator waveguides

T. Dupont[1], L. Grenouillet[1], P. Philippe[1], B. Ben Bakir[1], J.M. Fedeli[1], P. Grosse[1], A. Chelnokov[1]

[1]*CEA-LETI, MINATEC, 17 rue des Martyrs, 38054 Grenoble, France.*
tiphaine.dupont@cea.fr

Recently great efforts have been devoted to the development of laser sources closely integrated to Silicon in order to fabricate cheap and efficient optical links on CMOS. In this context we present the fabrication process of III-V lasers heterogeneously integrated on Silicon using die-to-wafer molecular bonding. We show the continuous-wave operation of electrically driven InGaAsP/InP Fabry-Pérot lasers (Figure 2) at room temperature and up to 35°C. We also propose several coupling schemes of the laser



CMOS Photonics

5th Optoelectronic and Photonic Winter School

15-21 March 2009

Sport Hotel Panorama

Fai della Paganella, Trento, ITALY

http://portale.unitn.it/events/cmosphotonics

helios

OPTOPRIM

PESEC Kyoto University

FBK Fondazione Bruno Kessler – Ricerca Scientifica e Tecnologica

University of Trento - Italy
Department of Physics
Nanoscience Laboratory

leti

GDR Ondes

ifn

DMD Department of Materials and Devices

Newport. Experience | Solutions

id Quantique

SiOF

PhoeniX

Spectra-Physics

BRUKER

LASERoptronic

PhotonFAB Support Action

THALES

Introduction

In its everlasting quest to deliver more data using smaller and lower cost components, the silicon industry is moving full steam ahead towards its final frontiers of size, device integration and complexity. For several years, **silicon-based photonic devices** have been widely considered to develop integrated circuits to overcome the microelectronic bottlenecks by combining existing silicon infrastructure with optical communications technology, and a merger of electronics and photonics into one integrated dual-functional device.
The challenge for **silicon photonics** is to manufacture low-cost information processing components by using standard and mature **CMOS technology**. Numerous photonic devices have already been developed in the last years to emit, propagate and distribute, modulate and detect light on silicon substrates. However, several obstacles should be overcome to foresee silicon photonics for the next generation high-speed systems.

The *5th Optoelectronic and Photonic Winter School* is dedicated to introduce, examine and review the recent achievements in the field covering fundamentals and devices, materials and technologies.

The School goals are:

1. to put the emphasis on the main building blocks towards a silicon photonics: from the light generation to the CMOS integration
2. to introduce PhD students and young researchers to this field and to determine the state of the art of silicon photonics, from the theory to the characterization with a point on the technology
3. to be a forum to exchange experiences about new advances and developments in the field thus promoting the scientific exchange between participants and contributors.

www.portale.unitn.it/events/cmosphotonics