Generic components for long-wavelength applications

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In recent years, the Photonics industry has evidenced a great interest for going toward Photonic Integrated Circuits (PICs) operating at wavelengths beyond 1.55 µm. The COBRA research group at the University of Eindhoven has initiated development of a generic integration platform functioning at wavelengths up to 2.1 µm. At present, our research is focused on Semiconductor Optical Amplifiers (SOAs), reversely biased phase shifters, passive waveguides and dense Spot-Size Convertor (SSC) arrays as building blocks for such a platform. Here we present results about several active materials tested in a Fabry-Pérot structure and lasing at wavelengths as long as 2.06 µm. In addition, some investigations are performed for lowering the loss level in passive waveguides via local Zinc diffusion restricted to the active areas.

Introduction

In photonics generic integration is a term referring to a technology where a wide variety of functionalities is achievable using a set of fully characterized building blocks such as passive components, lasers, optical amplifiers, detectors and modulators. In this framework, the InP-based technology [1] is of considerable interest since it supports the full range of building blocks. Since a few years ago when the InP-based generic approach was initiated for devices operating at 1550 nm, some important achievements have been obtained by our group and several other groups. This success has motivated us to develop a platform in which devices functioning at wavelengths around 2µm can be fabricated. The wavelength range around 2µm is of particular interest since there are a number of gas species (carbon dioxide, nitrogen dioxide, ammonia, methane) which have absorption peaks around this wavelength. Thus, the importance of having low-cost devices at long wavelengths provided though foundry runs in a generic platform for applications such as bio/chemo sensing is evident. In this paper we focus our study on active material test results for operation around 2µm wavelength together with some trials on local Zinc diffusion (P doping) for lowering the loss levels in passive structures.

Component case studies

1 – Long-wavelength active material

For this purpose a number of wafers with peak luminescence wavelengths over a range between 1.55µm and 2.1µm were provided by our partners Philips and the TU/e PSN group.
To examine these active materials a simple wide-area, Fabry-Pérot structure was used. Figure 1 is the schematic cross-section together with a top-view image of the fabricated structure.

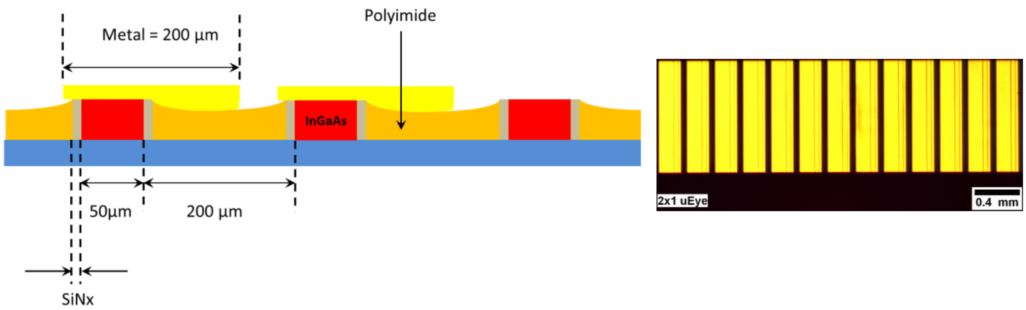

Figure 1 – (left) schematic side view of the wide-area Fabry-Pérot structure for test of the active material. (right) typical top-view image of a fabricated device.

The devices were cleaved in 1-mm long bars and mounted on a copper support. For measuring the laser characteristics the mounted chip was positioned on a copper block (water cooled down to 13 degrees) at the closest possible distance from the opening of an integrating sphere equipped with an InGaAs detector (Thorlabs, PDA10D). To avoid heating the devices were excited in a pulsed regime (frequency of 1 KHz and duty cycle of 2%) using a programmable pulse generator source (Agilent 8114A). The signal of the detector was monitored while scanning the output voltage of the pulse generator. For a homogeneous current distribution two probes were used to excite the devices.
Among the tested devices, the longest achieved wavelength belongs to a Sb-based Multi-Quantum-Well (MQW) InGaAs active material with laser emission at 2.06 µm (Figure 2).

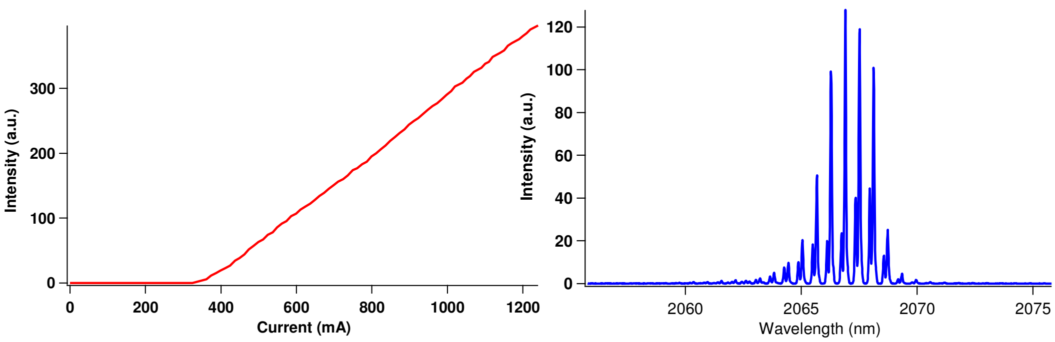

Figure 2 – (left) Laser emission characteristic curve of a 1-mm-long device with emission peak at 2.06 µm. (right) typical emission spectrum just above lasing threshold.

Antimony (Sb) plays the role of a surfactant in the active material growth. It enables bypassing the high compressive lattice strain originating from high concentrations of In which is required for getting long emission wavelengths [2].

2- Low-loss waveguides

The dominant loss mechanism in p-doped waveguides is the intervalence band transitions within the p-doped cladding layer [3]. Based on simulations (Figure 3, left) the dopant-induced losses become more prominent when going toward 2µm wavelength. If the unwanted doping above the passive waveguides can be removed then the loss level is considerably reduced. For this purpose we have initiated experiments for local Zinc (p dopant) diffusion restricted only to the active regions. To examine the Zinc diffusion, 30-µm-wide opening were etched through a 200-nm-thick SiNx layer which was used as a masking layer for the Zinc diffusion. After diffusion the sample was cleaved through the structures and the cross section was studied under the Scanning Electron Microscope (SEM) (Figure 3, right).

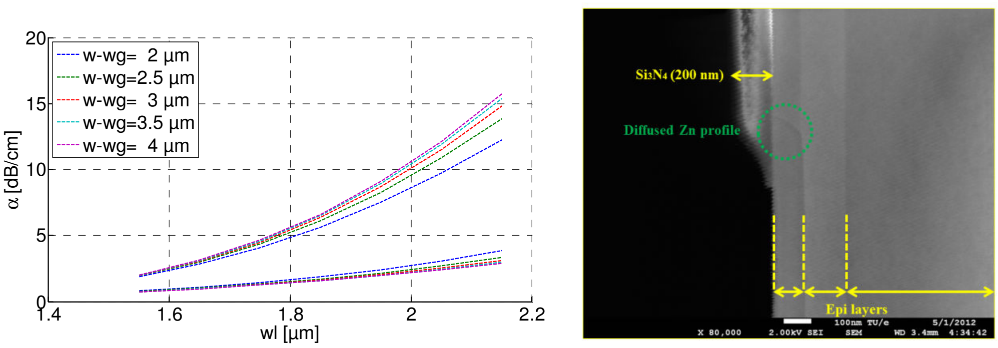

Figure 3 – (left) waveguide losses (dB/cm) as a function of wavelength for five different waveguide widths with and without p dopants. In the graph, the lower loss level corresponds to the case where no p doping is present above the passive waveguides. (right) SEM image showing the locally-diffused Zinc profile.

The control of diffusion depth for p dopants such as zinc is rather difficult since it is strongly dependant on diffusion time and temperature. According to simulations and our first observations, the results of the local Zinc diffusion are very promising for having reduced- loss passive components in future at long wavelength range and also to some extent at 1550 nm.

Summary

We have successfully demonstrated lasing emission of active materials around 2µm wavelength for integration in a long-wavelength generic platform technology. Preliminary results on local Zinc diffusion limited to the active regions show great promise to reduce the loss level in passive structures.

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