Towards a new platform for integrated optics: III-V photonic crystals bonded to silicon on insulator wire waveguides

Y. Halioua[1], F. Raineri[1,2], T.J. Karle[1], I. Sagnes[1], G. Roelkens[3], D. Van Thourhout[3] and R. Raj[1]

Laboratoire [1]de Photonique et de Nanostructures (CNRS UPR20), Route de Nozay, 91460 Marcoussis, France

[2]Université Paris-Diderot, 75205 Paris Cedex 13, France

[3]Ghent University – IMEC, Department of Information Technology, Sint-Pietersnieuwstraat 41, 9000 Ghent, Belgium

Silicon photonics is a rapidly developing platform for integrated optics. Combining the low-loss passive silicon photonic circuitry with III-V based active optical functionality, we can combine the best of both worlds. We investigate a new optical platform based on the heterogeneous integration of InP-based active 2D Photonic Crystals (PCs) on SOI waveguides.

The platform consists of a two level structure (Fig1) composed of SOI narrow waveguides (~500nm wide and ~200nm high) where the light propagates passively, and a 250nm InP membrane containing quantum wells. The light from the passive lower level couples in evanescently and interacts with the membrane to achieve the desired functionality (switching, amplification, laser…) and is then channelled out through the lower level.

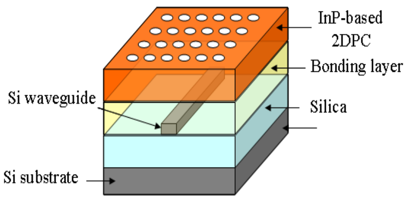

Fig 1. Schematic of the platform

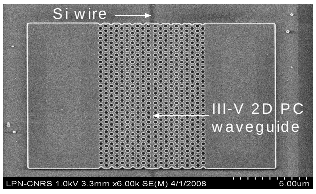

Fig 2. SEM of the 2DPCs aligned to SOI wires

The challenge to tackle is the fabrication of this "hybrid" structure. We opted for the adhesive bonding of the InP-based heterostructure on the SOI wires[2] using the planarising polymer BCB[1]. The success of the fabrication depends on the quality of the two parts and on the accuracy and the repeatability of the alignment of the PC structures with subjacent waveguides.

Silicon waveguides are fabricated using 193nm DUV lithography on SOI. Markers written on the mask level of the SOI waveguides allow us to align the electron beam lithography defined PC level, accurately to the Si waveguides. The PC is then patterned in the III-V membrane using reactive ion etching and inductively coupled plasma etching. Scanning electron microscopy measurements (Fig2) show that our 100nm long PC defect waveguides are aligned bang on top of SOI wires with accuracies better than 30nm!

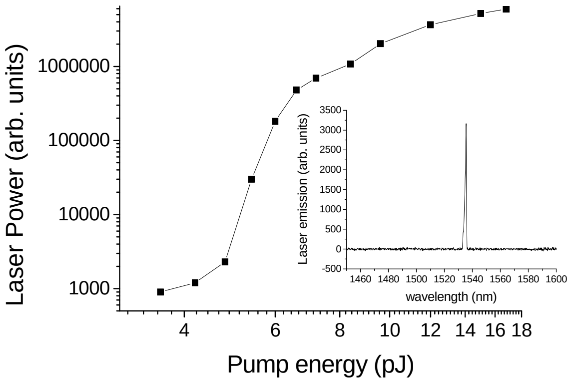

Fig 3. Laserlight-light (log-log) characteristics and spectrum

Laser emission from the 4 InGaAsP Quantum Wells embedded in the InP waveguide is coupled evanescently into the single mode Silicon waveguides and coupled out to single mode fibre via grating surface couplers [3]. Pulsed operation with a threshold of 5pJ gives a 1.2 fJ output power coupled into the fibre (fig 3).The slow mode of the photonic crystal contributes not only an enhancement to the optical gain but also a reduction of the coupling length between the waveguides.

References

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[3] http://www.epixfab.eu/ - the silicon photonics platform

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