# Laser Emission from Heterogeneously Integrated InP Photonic Crystals into SOI Wires

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

[1] *Groupe Photoniq, Laboratoire de Photonique et de Nanostructures - CNRS, Marcoussis, France,*
[2] *UniversiteParis Diderot ,Paris, France,*
*Timothy.Karle,Yacine.Halioua,Fabrice.Raineri, Isabelle.Sagnes, Rama.Raj @lpn.cnrs.fr*
[3] *Photonics Group, UGent-INTEC, Gent, Belgium*
*dries.vanthourhout, frederik.vanlaere, gunther.roelkens @intec.ugent.be*

The heterogeneous integration of active III-V photonic crystal waveguides and passive Si wire waveguides is demonstrated. Laser action is observed in the InGaAsP/InP layer at 1535nm which is coupled out via the DUV processed Si wire waveguides [1]. The development of Si photonics as a platform for integrated optics benefits enormously from years of CMOS processing expertise, producing waveguides with losses as low as 0.92dB/cm [2]. As Si possesses an indirect electronic bandgap it is relatively unsuitable for light emission. III-V materials such as InP, are efficient light emitters. Their patterning with a periodic photonic crystal can yield substantial control over the optical density of states, and thus further increase their efficiency. The compelling problem is that of coupling the light emitted into a passive waveguide, to avoid interband absorption. Recently all-III-V photonic crystals have been demonstrated where the nano-cavity and passive waveguide are butt-coupled together [3]. In our work we offer an innovative solution, which is to evanescently couple between an accurately aligned InP PhC and a Si waveguide.

The two optical levels of the system are bonded together using an adhesive bonding agent BCB [4]. High accuracy alignment of the subsequently written InP photonic crystal pattern is realised by means of reference markers written on the Si level. These are rendered visible to our 100keV electron beam writing system and relative alignment between the levels is deduced from SEM images, and is found to be 30±7nm. An investigation of the planarising properties of the BCB is carried out after each processing step using Dektak and AFMicroscopy. Fabrication steps are detailed with regards to the transfer of the critical parameters of the system. Laser emission, from the 4 InGaAsP/InGaAs QWs embedded in the InP waveguide, is coupled evanescently into the single mode Si waveguides and coupled out to single mode fibre via grating surface couplers. The samples are optically surface pumped using a Ti:Sa laser delivering 100fs pulses at 800nm at a repetition rate of 80MHz, the light-light characteristic (see Fig. 2) displays a threshold of about 5pJ. 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.

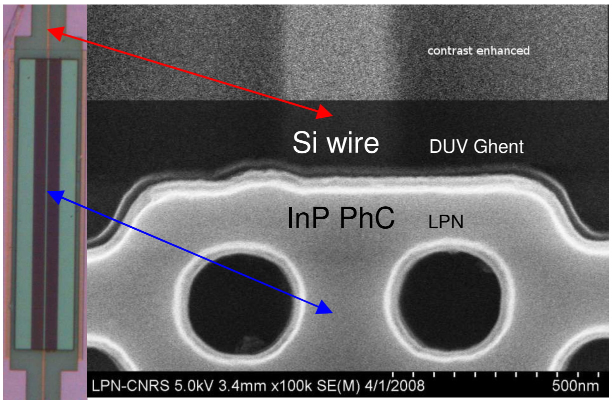


*Fig. 1: Optical and SEM images showing 90μm long InP PhC and underlying Si wire*

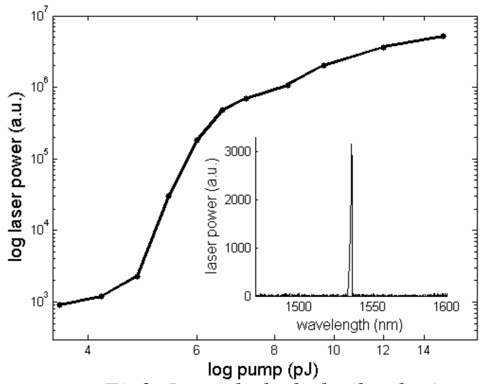


*Fig2. Laser light-light (log log) characteristic and spectrum*

## References

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