40 Gb/s Wavelength Division Demultiplexing with a PhC Filter
Sylvain Combrié, Gaëlle Lehoucq, S. Xavier, Alfredo De Rossi, Kevin Lenglé, Laurent Bramerie, Mathilde Gay, Jean-Claude Simon, Gaetano Bellanca, Stefania Malaguti, et al.

To cite this version:

HAL Id: hal-00720241
https://hal.archives-ouvertes.fr/hal-00720241
Submitted on 24 Jul 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
40 Gb/s Wavelength Division Demultiplexing with a PhC Filter

(1) Thales Research and Technology, 1 Avenue Augustin Fresnel, 91767 Palaiseau, France,
(2) Université européenne de Bretagne, 5 Boulevard Laennec, 35000 Rennes, France
(3) CNRS Foton (UMR 6082), BP 80518, 22305 Lannion cedex, France
(4) University of Ferrara, Via Saragat, 44122 Ferrara, Italy,

Abstract: We have designed and fabricated a photonic crystal filter intended for demultiplexing in wavelength division domain. This device is single-mode, the total insertion losses are about 12dB and the channel isolation can exceed 25dB. Non return to zero signal at 40Gb/s have been successfully filtered with no penalty in the bit error rate analysis. The device is cascadable to form a multi-channel demultiplexer and can be tuned through an integrated, low power temperature controller.

1. Introduction
High-quality and very small volume optical cavities are an attractive feature of the Photonic Crystal (PhC) technology [1]. That enables true single-mode resonators, e.g. with very large free-spectral range, which are therefore suitable for integrating filters, particularly for WDM applications [2].

Single [3] and multi-channels [4,5] optical filters based on this technology have been demonstrated. Drop efficiencies exceeding 50% (relative to the bus) and cross-talk rejection better than 25dB have also been reported.

Here we report the elementary bricks in order to achieve a WDM filter knowing a low loss drop filter, a tunable filter and the measurement of the transmission and filtering of NRZ data signal at 40 Gb/s.

2. The Photonic Crystal Technology

![Fig. 1. SEM image of the WDM filter with one drop channel. The white dashed line indicates the area where the single mode resonant cavity is located.](image)

Our devices are PhC chips based on the III-V technology. That enables the future integration of light emitting devices, with the potential of ultra-low power consumption, as demonstrated by the NTT group [6]. On this platform, we have demonstrated a processing quality comparable to Silicon, e.g. we achieved a Q-factor exceeding one million [7].

In order to reduce the total insertion losses, we have improved the fiber to PhC coupling using integrated mode adapters (loss is about 2.5 dB per face in TE mode) and we have optimized the cavity to the waveguide coupling in order to reach the optimal drop efficiency, namely 50% in our 3-ports, single resonator design, shown in fig. 1, representing our best result.

![Fig. 2. Transmission through the drop and the bus channels, normalized to the maximum bus transmission.](image)

We have measured the transmission through the bus and the drop channels and normalized to a common reference, that is the maximum transmission in the bus channel, as shown in fig. 2. The drop transmission is very close to 50% and the resonance follows the Lorentzian lineshape over more than 3 decades. Outside the resonance, the signal through the drop is below 30dB or not measurable all over the PhC waveguide transmission range, namely 50 nm. Finally, the total insertion loss, from the input fiber to the output fiber on the drop channel is about 12dB, thereby including fiber to PhC input and output coupling loss, propagation loss and the intrinsic drop efficiency.
3. Tuneability
On the same technological platform, but not so far the
same sample, as shown in figure 1, we demonstrated the
tunability of the resonator through integrated electric
heaters. As a voltage is applied, the cavity resonance is
tuned with a consumption of 0.7mW of electrical power
per 1 nm of wavelength shift (Fig. 3).

The result is reported in fig. 4, along with the eye-
diagrams. No penalty can be attributed to the filter, as
the three curves basically superimpose.

7. Conclusions
We have developed optical filters for wavelength
domain demultiplexing based on a semiconductor
photonic crystals technology. We have reported,
although not yet in the very same sample, the
achievement of a tunability, the lowering of the total
insertion losses down to 12 dB, the reaching a drop
efficiency up to 50% and 30 dB cross-talk isolation.
In the first generation of this devices, we have performed
BER measurements with data signal at 40Gb/s, showing
not additional penalty after the transmission through the
filter (both drop and bus channels). Furthermore, we
estimate to 1 mW the electric power budget for
accurately tuning our filter. The next step will consist in
combining all these features on the same chip and
demonstrate a tuneable multi-channel WDM
demultiplexer.

Acknowledgement
We acknowledge the European Union, FP7/ICT funding
programme, under the COPERNICUS project (249012).

References
photonic nanocavity in a two-dimensional photonic crystal”,
“Channel drop filters in photonic crystals”, Opt. Expr., 3,
efficient multi-channel drop filter in a two-dimensional
“Ultrasmall multi-port channel drop filter in two
dimensional photonic crystal on silicon-on insulator
Segawa, T. Sato, Y. Kawaguchi, M. Notomi, “High-
speed ultracompact buried heterostructure photonic-
crystal laser with 13 fJ of energy consumed per bit
Rossi, “High quality GaInP nonlinear photonic crystals
with minimized nonlinear absorption”, Appl. Phys. Lett.,
95, 221108 (2009).