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Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Optical Time Domain Demultiplexing using Fano Resonance in InP Photonic Crystals

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Ultra-compact photonic structures that perform high-speed low-energy optical signal processing are essential for enabling integrated photonic chips that can meet the growing demand for information capacity [1]. Here, we demonstrate all-optical 40 Gbit/s to 10 Gbit/s demultiplexing of an optical time domain multiplexed (OTDM) signal using an InP photonic crystal switch. The device is realized using a membrane structure, where a point-defect nanocavity is side coupled to a photonic crystal line-defect waveguide as shown in Fig. 1(a). The discrete cavity mode interacts with continuum modes of the waveguide creating a Fano resonance [2]. By placing a partially transmitting element (PTE) in the waveguide, the coupling between the waveguide and the cavity can be controlled [3]. The Fano lineshape is characterized by a large on-off transmission ratio with small spectral separation making it suitable for switching applications (Fig. 1(b)).

A 40 Gbit/s OTDM data signal is coupled to the device together with a 10 GHz pump pulse. When the pump pulse couples into the nanocavity, free carriers are generated by two-photon absorption, which induce a blue shift in the resonance frequency through plasma dispersion and bandfilling effects [4], allowing the OTDM signal to transmit through the waveguide. The eye diagrams of the OTDM signal, pump pulse and the demuliplexed channels are shown in Fig. 1(c). The demultiplexed channel has an extinction ratio of 3 dB.

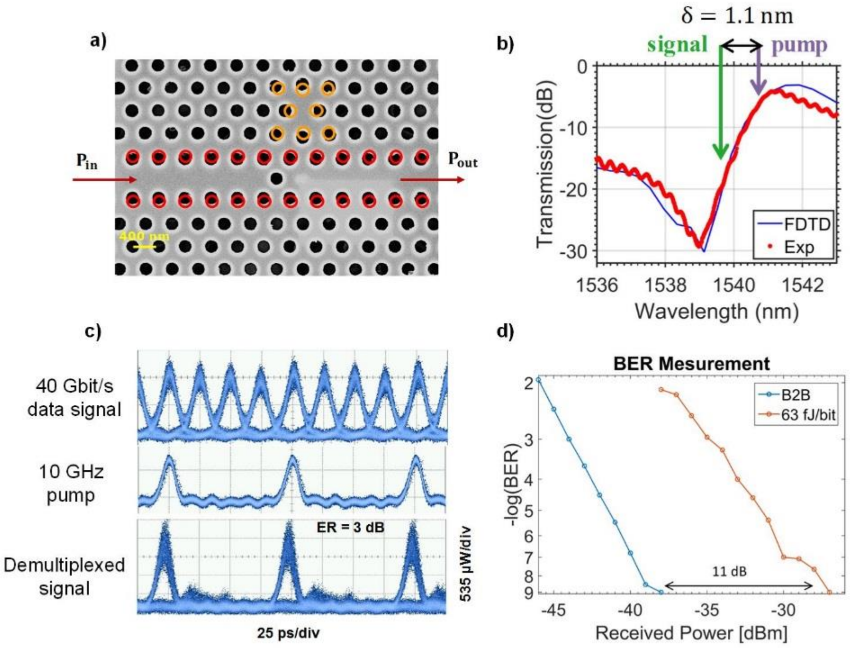

Fig. 1 (a) Scanning electron microscope (SEM) image of the device. The positions of the inner rows of holes and around the nanocavity have been optimized compared to the periodic structure (illustrated by coloured circles). (b) Experimentally measured transmission spectrum and finite difference time domain (FDTD) fitting. The pump and the signal are spectrally separated by 1.1 nm. (c) eye diagrams of the 40 Gbit/s input OTDM data signal, the 10 GHz pump signal and demuliplexed signal (d) BER measurement for demultiplexed signal, corresponding to a pump energy of 63 fJ/bit, and back-to-back (B2B) measurements.

Bit-error-ratio (BER) measurements (Fig. 1(d)) of the 10 Gbit/s demultiplexed signal clearly show *error-free* performance with power penality of ~ 11 dB at a BER of 10^{-9} compared to a 10 Gbit/s back-to-back (B2B) with switching energy of 63 fJ/bit. These results show the potential of Fano resonance based InP photonic crystal switches for fast and energy efficient all-optical data communication applications. At the conference, the prospects of realizing demultiplexing at higher data rate such as 100 Gbit/s will be discussed.

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