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Transparent switching in PPLN waveguide arrays

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Abstract: Ultrafast all-optical switching and routing based on quadratic parametric interaction is experimentally demonstrated in PPLN waveguide arrays. Milliwatt signals at 1550 nm can be switched to different positions and wavelengths with low cross-talk.

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We present the experimental realization of a recently proposed scheme for phase-insensitive all-optical switching and routing of low power signals in waveguide arrays with second-order nonlinearity [1]. Based on the combination of parametric frequency down conversion and the unique properties of discrete diffraction [2] we demonstrate the simultaneous frequency conversion and spatial switching of low power signals to different output positions of a waveguide array.

The spatial switching is based on the interaction of two diffractionless beams (see Fig. 1). The pump beam is resting in a single waveguide since its short wavelength results in strongly confined modes without overlap with neighboring guides. In contrast the signal modes couple, which allows for a crossing of the array. However as a special feature of discrete diffraction, beam spreading virtually disappears at a certain angle. Parametric interaction at the intersection point results in the amplification and deflection of the signal and generation of a frequency shifted idler. Position and wavelength of the idler output can be controlled by the position and wavelength of the pump input.

The experiment was performed in arrays of 101 titanium diffused waveguides on 5-cm-long Z-cut lithium niobate crystals (signal coupling lengths: ≈5 mm). An electric field poled QPM grating of 16.8 µm realized phase-matching of the TM_{00} mode of the pump (λ_P=774.35 nm) with the TM_{00} mode of the signal ($\lambda_S\approx$1548.7 nm–Δ) and the idler ($\lambda_I\approx$1548.7 nm+Δ) at a crystal temperature of 215°C [3]. The 8.5-ps-long transform limited pump pulses (peak power: up to 65 W, repetition rate: 76 MHz) were generated by frequency doubling a NaCl color center laser. The signal was provided by a tunable cw laser diode, to avoid the problem of synchronizing two pulsed lasers in this laboratory demonstration. The output of the array was characterized by spatially resolved scanning of the spectrum (see Fig. 2).

For a pump input power of 50 W a 20 mW signal beam was switched to idler output pulses of 20 mW peak power – hence, realizing a fully transparent switching device. Above 50 W pump power the devices even provided for parametric gain. In Fig. 3a the spatial output distribution of the idler is shown for different input positions of the pump. It demonstrates that four different output positions can be addressed without significant cross-talk. The simultaneous wavelength conversion of the idler is verified in Fig. 3b with a bandwidth exceeding 20 nm. The undistorted output spectra together with detailed simulations confirmed the ultrafast switching capability without significant pulse-distortion up to a data-rate of 100 GHz. However, the experimental verification of this figure is beyond our laboratory equipment.

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[1] T. Pertsch, U. Peschel, and F. Lederer, “All-optical switching in quadratically nonlinear waveguide arrays,” Opt. Lett. 28, 102 (2003).

[2] T. Pertsch, T. Zentgraf, U. Peschel, A. Bräuer, and F. Lederer, “Anomalous refraction and diffraction in discrete optical Systems,” Phys. Rev. Lett. 88, 093901 (2002).

[3] G. Schreiber, H. Suche, Y. L. Lee, W. Grundkötter, V. Quiring, R. Ricken, and W. Sohler, “Efficient cascaded difference frequency conversion in periodically poled Ti:$LiNbO_3$ waveguides using pulsed and cw pumping,” Appl. Phys. B 73, 501 (2001).

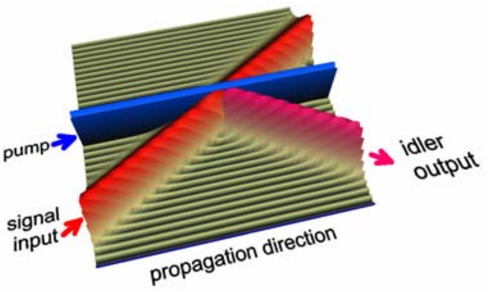

Fig. 1. All-optical switching of an input signal beam to a specific output position of a frequency shifted idler using parametric interaction with an independent pump in a quadratic nonlinear waveguide array.

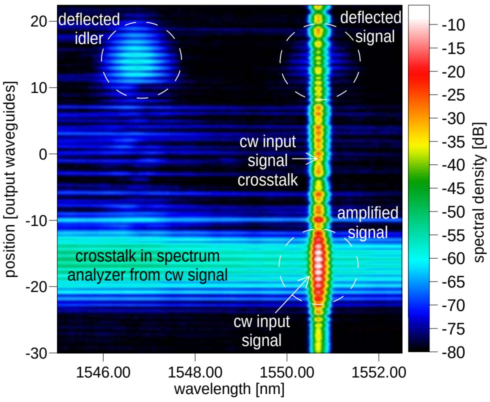

Fig. 2. Spatial-spectral scan of the output of a PPLN waveguide array after parametric interaction of a signal beam (λ_S=1550.7 nm) and a pump beam (λ_P=774.35 nm) which generates an idler (λ_I=1546.7 nm).

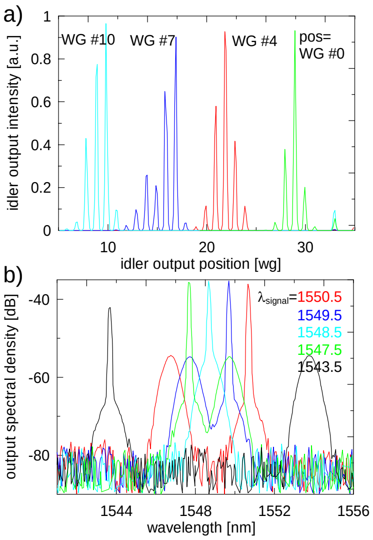

Fig. 3. a) Spatial idler output distribution for different positions of the input pump beam. b) Spectral output distribution of signal and idler from the waveguide with the maximum generated idler for a number of different signal wavelengths. The narrow high-power peak results from the cross-talk of the cw signal input.