Proc. Conference Lasers and Electro-Optics (CLEO/Europe '03), Munich/Germany, paper CE5-1-THU

Efficient, all-optical wavelength conversion and tuning of ps-pulses in a Ti:PPLN channel waveguide

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Abstract: All-optical wavelength conversion of –4.7 dB efficiency and 100 nm tuning range is demonstrated based on cascaded sum and difference frequency generation in a Ti:PPLN channel waveguide.

Optical wavelength converters are key elements for future WDM network. Among various wavelength conversion schemes proposed, wavelength conversion based on cascaded sum and difference frequency generation (cSFG/DFG) in a Ti:PPLN channel waveguide is especially promising. It offers a broad tuning bandwidth covering optical communication window, low spontaneous emission noise, and ultrafast operation speed. We successfully demonstrated all-optical wavelength conversion and tuning of 5-ps pulses using cSFG/DFG [1]. However, the conversion efficiency was as low as less –23 dB in a tuning range of 50 nm. Moreover, the pulses were severely distorted and broadened after the conversion. In this contribution a significant improvement of conversion efficiency, tuning range and pulse quality is reported. It was achieved by using a Ti:PPLN channel guide of broad bandwidth for SFG and, therefore, of reduced effective nonlinear interaction length.

A 5.5 cm long Ti:PPLN channel waveguide of 16.6 µm microdomain period was prepared. Second harmonic generation (SHG) phase matching wavelength and conversion efficiency are 1546 nm and 270 %/W, respectively, at 200 ^{o}C. The effective interaction length is ~27 mm calculated from the SHG bandwidth of $\Delta\lambda$=0.41 nm.

5-ps transform limited gaussian pulses (λ_s) were superimposed with two cw pump waves (λ_{p1}, λ_{p2}) by a 10/90 coupler and launched together into the channel guide by fiber butt-coupling. The pulsed signal and the pump (λ_{p1}) generate sum frequency pulses (λ_{sf}) perfectly phase matched. At the same time, a second pump (λ_{p2}) interacts with the sum frequency wave (λ_{sf}) to generate idler pulses (λ_i) by DFG. This process is slightly phase mismatched, but the conversion efficiency is only slightly reduced in comparison to a phase matched interaction. The idler wavelength can be tuned by the wavelength of the second pump.

Fig. 1 shows the optical spectra for two different wavelengths of the second pump, measured with 0.1 nm resolution. The power levels of both pump waves were controlled to be equal (~275 mW); the coupled power of the signal was 1.6 mW. The conversion efficiency from the signal to the generated idler was measured to be –4.7 dB. When the wavelength of the second pump (λ_{p2}) was varied from 1533 nm to 1568 nm, the idler wavelength was tuned from 1524 nm to 1559 nm almost linearly. In this wavelength range, no significant change of the conversion efficiency was found (Fig. 2). The theoretical calculation predicts a very wide tuning range of more than 100 nm. The broadening of the idler pulses due to group velocity mismatch (3 ps/cm) was investigated theoretically. Numerical simulations showed ~28 % pulse broadening.

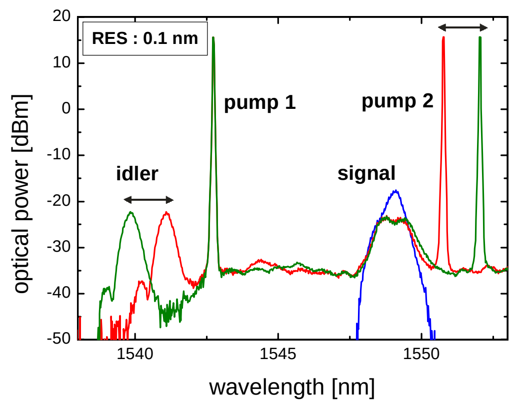

Fig. 1: Optical spectra of signal and idler at different pump 2 wavelengths.

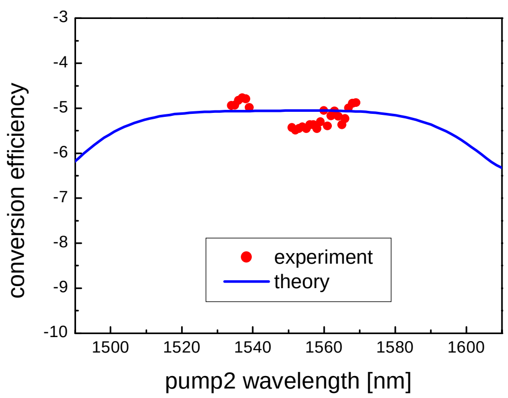

Fig. 2 : Idler to signal conversion efficiency as function of pump 2 wavelength

[1]: Y. H. Min at. el. OFC 2003.