티타늄 확산 주기적 분극반전 채널 광도파로에서 연속적으로 일어나는 합주파수/차주파수 생성을 이용한 가변 파장 변환기

Tunable All-Optical Wavelength Conversion in a Ti:PPLN Channel Waveguide Using Cascaded Sum and Difference Frequency Generation

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The wavelength converter is considered to be a key element of future dense WDM optical networks. It enables wavelength reuse and resolves contention problem. Moreover, the tunability of the wavelength converter enhance the flexibility of network systems by facilitating reconfigurable dynamic wavelength routing[1,2]. In order to achieve optically tunable wavelength conversion, we recently proposed and experimentally demonstrated wavelength conversion and tuning based on cascaded sum and difference frequency generation in a Ti:PPLN channel waveguide[3]. Fig. 1 shows the schematic diagram of the operational principle of the device exploiting cSFG/DFG process. The signal (λ_s) and the pump (λ_p) generate the sum frequency (λ_{sf}) perfectly phase matched. At the same time a control wave (λ_c) interacts with the sum frequency wave (λ_{sf}) to generate an idler (λ_i) by DFG. The coupled wave equations for these nonlinear optical processes were numerically solved using 4th-order Runge Kutta method. Fig. 2 presents the calcuated idler power as function of pump and control powers for a 6 cm long channel waveguide. The idler to signal conversion efficiency is calculated to be -1.12dB with a pump power of 460 mW.

To demonstrated all-optical wavelength conversion by cSFG/DFG, a 8.3 cm long Ti:PPLN channel waveguide of 16.6 μm microdomain periode was fabricated. SHG phase matching wavelength and conversion efficiency are 1546.37 mm at 153.3 °C and 400 %/W, respectively. Two pump waves (λ_p=1558.46 nm, λ_c=1559.6 nm) were combined by a 3 dB coupler and simultaneously amplified by using an EDFA, resulting in equal power levels. A signal wave (λ_s=1534.28 nm) was superimposed by a 10/90 coupler and launched together with the pump waves into the channel guide. The transmitted signal and generated idler (λ_i= 1533.46 nm) were observed as function of the pump power using an optical spectrum analyzer.

Fig. 3 shows some experimental results with signal and idler power as function of both pump and control power level in the inset. The maximum conversion efficiency was 3.3 dB, defined as the ratio of generated idler power to transmitted signal power at zero pump; it was obtained with 780 mW coupled power, 390 mW for each one.

With fixed wavelengths of pump (λ_p=1558.46 nm) and signal (λ_s=1534.28 nm) the idler wavelength could be changed by tuning the control wavelength. Fig. 4 shows the corresponding experimental result fitted with a theoretical response. In the experiment the coupled pump power was 200 mW for both pump waves. The control wavelength was tuned from 1546.24 nm to 1567.24 nm, resulting in an idler wavelength from 1546.5 nm to 1525.5 nm. The theoretical result predicts an even wider tuning range of more than 60 nm.

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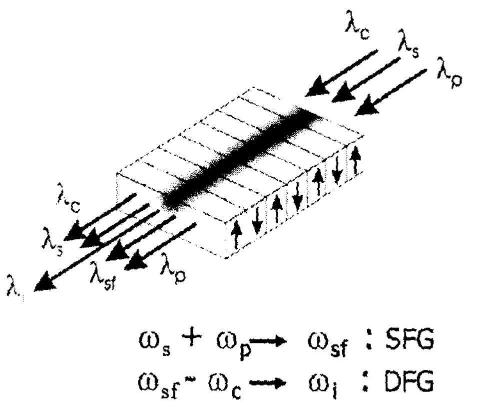

Fig. 1. Schematic diagram of cSFG/DFG in a Ti:PPLM channel waveguide.

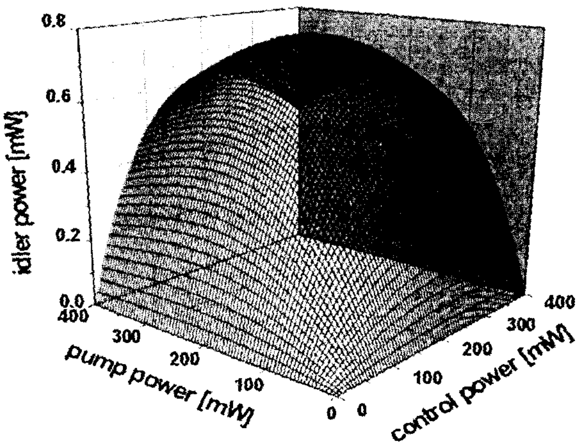

Fig. 2. Generated idler power versus pump and control powers.

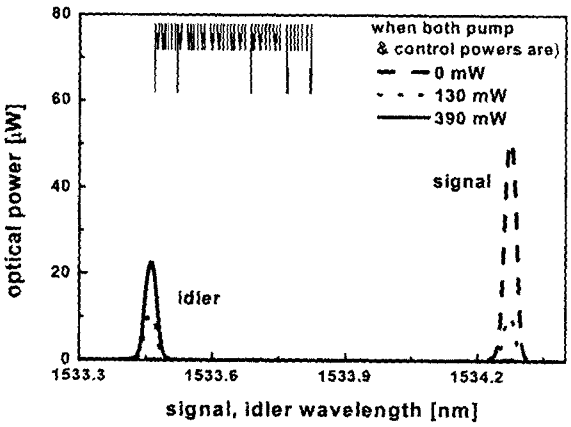

Fig. 3. Optical spectra of signal and idler at different pump power levels. Inset: the transmitted signal and the generated idler power as fuction of the pump power

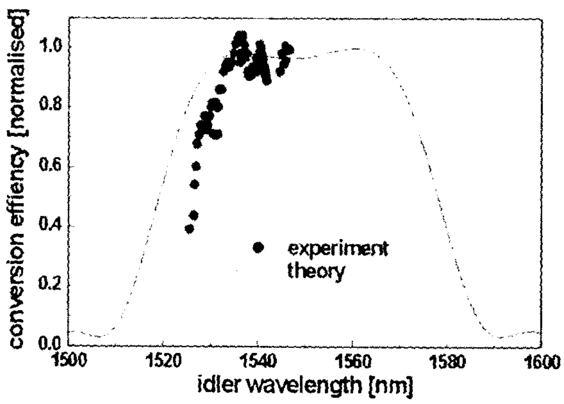

Fig. 4. Normalized conversion efficiency of cSFG/DFG with fixed signal and pump wavelengths versus idler wavelength