Experimental Study on the Impact of Spectrum Slicing on Pulsewidth

Bo Wang, Guiling Wu, Jianping Chen, Xinwan Li

State Key Laboratory of Advanced Optical Communication Systems and Networks,
Shanghai Jiao Tong University, Shanghai 200240, People's Republic of China
Corresponding Author Email: wuguiling@sjtu.edu.cn

Abstract: We experimentally study the impact of spectrum slicing on pulsewidth for the generation of multi-wavelength pulses. Pulse broadening caused by spectral filtering and dispersion is analyzed and compared.

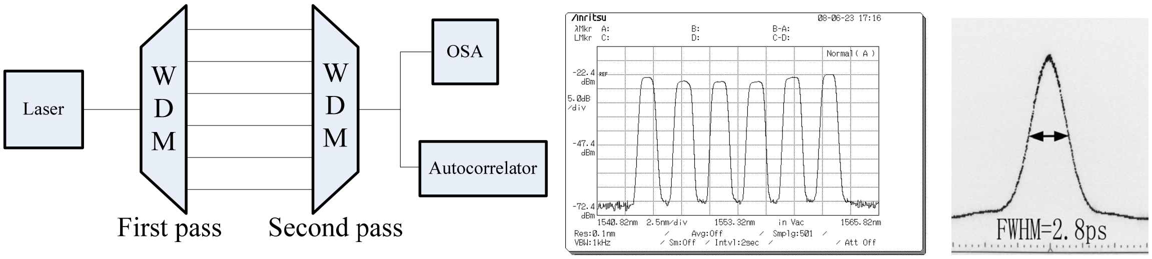
OCIS codes: (060.4510) Optical communications; (230.7408) Wavelength filtering devices; (260.2030) Dispersion

1. Introduction

Spectrum slicing has been widely used to generate multi-wavelengths pulses for WDM transmission [1, 2], OCDMA system, and photonic analog-to-digital converters (ADCs) [3-5]. In this work, we have taken further investigations and comparative experiments to study the impact of spectrum slicing on pulsewidth.

2. Experiment results

Our experiment setup is shown in Fig.1 (a), which utilizes spectrum slicing to generate multi-wavelength pulses. The optical pulse source is a femtosecond fiber ring laser with 40M repetition rate. The output optical pulse has a temporal full width at half maximum (FWHM) of 70fs and a spectral bandwidth of 40nm, indicating a nearly transform-limited Time-Bandwidth Product (TBP) of 0.35 and hyperbolic secant pulse profiles. 6 wavelength channels have been used in our experiment for spectrum slicing. Fig.1 (b) shows the output spectrum and (c) shows the typical autocorrelation trace in one channel after spectrum slicing.



(a) (b) (c)

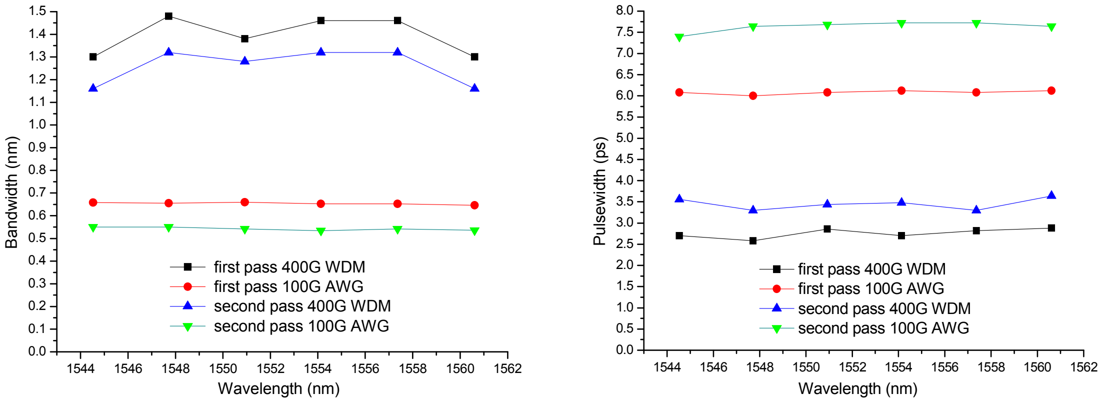
Fig.1. (a) Experiment setup (b) Output spectrum (c) Typical output autocorrelation trace

We perform spectrum slicing with a 400GHz channel spacing WDM (400G WDM) and a 100GHz channel spacing AWG (100G AWG) respectively to make comparisons. The 400G WDM has a 3dB channel bandwidth of 1.4nm, while the 100G AWG has a 3dB channel bandwidth of 0.64nm.

For a typical channel output, the pulse after spectrum slicing by 400G WDM has a FWHM pulsewidth of 2.8ps (calculated from autocorrelation trace), and spectral bandwidth of 1.4nm. While for 100G AWG, the output pulse has a FWHM pulsewidth of 6ps and spectral bandwidth of 0.64nm.

After spectrum slicing to generate parallel wavelength channels, the 6 channels pass the second WDM to form a serial pulse train. Because the wavelength filters don't have rectangular transmission profiles, each channel will be filtered again when passing through the WDM for the second time, resulting in narrower spectral bandwidth and broader pulse width. For 400G WDM, typical pulsewidth in one channel increases from 2.8ps to 3.6ps for the second pass through WDM. While for 100G AWG, pulsewidth increases from 6ps to 7.6ps.

For a comprehensive study, we have measured 6 channels output pulsewidth and 3dB spectral bandwidth for 400G WDM and 100G AWG respectively, under the condition of first and second pass. Results are shown below in Fig.2 (a) and (b). Fig.2 (a) shows the spectral bandwidth in each channel and Fig.2 (b) shows the corresponding pulsewidth. From Fig.2, it is obvious that the pulsewidth in each channel is inversely proportional to the channel bandwidth, indicating that the time-bandwidth product (TBP) in each channel is maintained constant when being spectrum sliced by different wavelength filters.



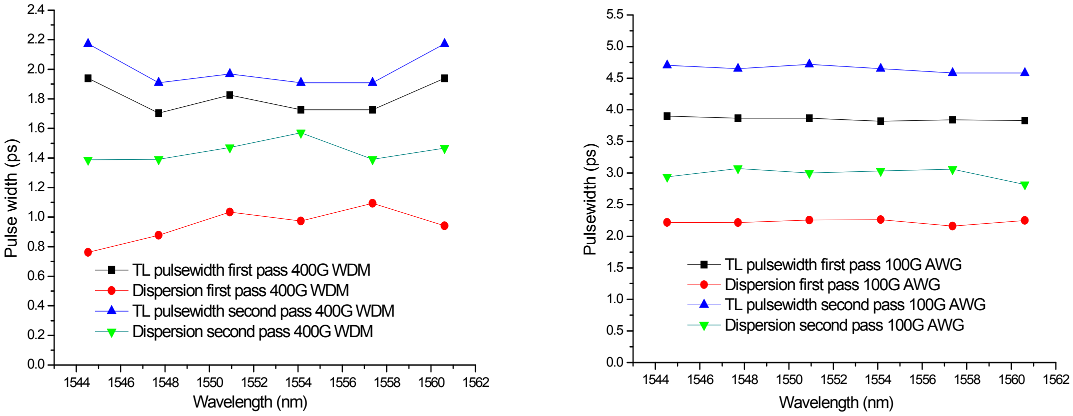
(a) (b)

Fig.2. (a) Spectral bandwidth and (b) Pulsewidth after first and second pass through 400G WDM and 100G AWG

3. Analysis

By using wavelength filters with a broad 3dB channel bandwidth, ultrashort optical pulse could be generated to form high speed pulse trains. But this requires the channel spacing to be large enough, therefore resulting in fewer wavelength channels that could be sliced out of the source spectrum. For example, with 400GHz (3.2nm) channel spacing WDM, we can get as short as 3.6ps pulses. But with our 40nm spectrum, we could only slice 12 wavelength channels from the source.

Assuming a hyperbolic secant pulse profile after spectrum slicing, transform-limited (TL) pulsewidth in each channel could be calculated and the difference between measured pulsewidth and transform-limited (TL) pulsewidth could be mainly attributed to dispersion. The calculated transform-limited (TL) pulsewidth and the pulsewidth broadening caused by dispersion in each channel are shown below in Fig.3 (a) and (b) for 400G WDM and 100G AWG respectively, under the condition of first and second pass through the wavelength filter. It is obvious that the accumulated dispersion after the second pass through WDM and AWG is significant compared with the transform-limited (TL) pulsewidth, implicating that shorter pulsewidth could be generated by dispersion compensation.



(a) (b)

Fig.3. Transform-Limited (TL) pulsewidth and pulsewidth caused by dispersion after first and second pass (a) 400G WDM and (b) 100G AWG

4. Conclusion

We have experimentally studied the performance of spectrum slicing with a comparison between 400GHz channel spacing WDM and 100GHz channel spacing AWG, and verified that the pulse width after spectrum slicing is inversely proportional to the channel bandwidth. Another factor contributed to pulse broadening in spectrum slicing is dispersion caused by the wavelength filters. Analysis of the impact of both spectral filtering and dispersion on pulse width broadening is presented.

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