# 40 Gbit/s SOA-based wavelength conversion assisted by a narrow optical bandpass filter

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*All-optical wavelength conversion at a bit-rate of 40 Gbit/s is demonstrated by using an SOA that has a recovery time of more than 100 ps in combination of a narrow optical bandpass filter. We obtain a clear open eye-pattern in case of wavelength conversion using return-to-zero data if the central wavelength of the optical bandpass filter is located at the blue-shifted sideband of the converted signal. We experimentally show that the eye-pattern becomes closed if the central wavelength of the optical bandpass filter is tuned to the peak of the converted signal. Our results indicate that the operating speed of SOA-based wavelength conversion can be increased by a properly selected spectral filter.*

## Introduction

All-optical wavelength converters that utilize the nonlinearity of semiconductor optical amplifier (SOA) have attracted considerable research interest [1]. In current SOA-based wavelength converters, the relatively slow recovery time of the carrier density (typically several hundred picoseconds), limits the maximum operating speed.

Several technologies have been used to improve the bandwidth of SOA-based wavelength converters. In [2], it has been demonstrated that by using a very long SOA (2 mm) wavelength conversion at 100 Gbit/s can be achieved. In [3], a differential Mach-Zehnder Interferometer scheme with SOAs in both arms has been proposed. In this configuration, a short switching window (several picoseconds) can be generated although the SOA in each arm has a relatively slow recovery of the carrier density. In [4], a delay-interferometric wavelength converter has been demonstrated in which only one SOA is utilized.

In this paper, we show a very simple wavelength converter that operates at 40 Gbit/s, by only utilizing a narrow optical bandpass filter and a commercial SOA that has recovery time of more than 100 picoseconds. A clear open eye-pattern of the converted signal has been realized at 40 Gbit/s, indicating that a narrow bandpass filter can be used to increase the bandwidth of the SOA-based wavelength converter.

## Experiment and results

The experimental set-up is shown in Figure 1. As shown in the dashed box of Figure 1, the proposed wavelength converter is made out of one SOA and an optical bandpass filter. The SOA employed is a commercially available strained bulk device with an active length of SOA is 800 μm. The SOA provides 20 dB fiber-to-fiber gain when it is pumped with 400 mA of current. The optical bandpass filter has a 3dB-bandwidth of 0.42 nm.

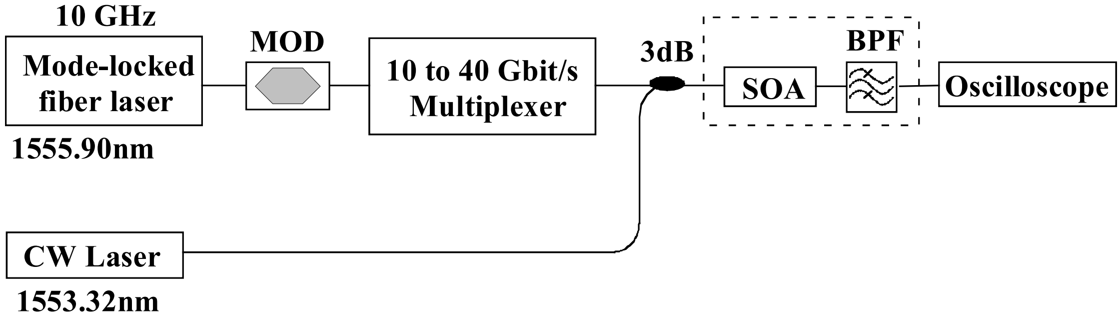


***Figure 1.*** *Experimental setup. MOD: extern modulator, SOA: semiconductor optical amplifier, BPF: optical bandpass filter.*

As shown in Figure 1, a stream of optical pulses at a bitrate of 10 Gbit/s, generated by an active mode-locked fiber ring laser, is firstly modulated by an external modulator at 10 Gbit/s, forming a data stream with a $2^{31}-1$ return-to-zero (RZ) psesudorandom binary sequence (PRBS) format. This data stream is multiplexed to 40 Gbit/s via a passive fiber-based interleaver. The 40 Gbit/s RZ data signal is combined with a continuous wave (CW) probe signal and fed into the SOA via a 3 dB coupler. The average optical power that is injected into the SOA is 2.5 dBm for the 40 Gbit/s data stream, and 6.3 dBm for CW probe light. As shown in Figure 2a, the center wavelength of the 40 Gbit/s RZ data signal and CW probe light is 1555.90 nm and 1553.32 nm, respectively. In the SOA, the 40 Gbit/s data signal modulates the SOA carrier density, and thus the SOA gain. As a result, the gain of the input CW probe light is also modulated via cross-gain modulation [1]. Thus inverted wavelength conversion is realized. On the other hand, the injected 40 Gbit/s data signal simultaneously modulates the refractive index of the SOA, resulting in a chirped converted signal. As a result, the falling edge of the inverted probe signal is shifted to longer wavelength (red-shifted) and the rising edge is shifted to short wavelength (blue-shifted) [1]. Thus, the spectrum of probe light is broadened at the output of the SOA, as indicated in Figure 2b. At the output of the SOA, an optical filter selects the blue sideband of the probe light. The characteristic of the optical filter is indicated by the dashed-line in Figure 2b. Figure 2c shows the optical spectrum of the probe light at the output of the optical filter.

The converted 40 Gbit/s signal is measured by an Agilent/HP 86100A digital communication analyzer with a 55 GHz O/E converter. The results are presented in Figure 3. On the left column of Figure 3, a clear 40 Gbit/s eye-pattern is shown, indicating that error-free conversion is possible. The oscilloscope traces of the 40 Gbit/s converted signal is shown in the right column of Figure 3. No pattern-dependent effect is observed. A critical point in our approach is to select the blue sideband of the broadened spectrum of the probe light. We have also tuned the center wavelength of the filter to the peak of the spectrum of the converted probe light. The result is presented in Figure 4a. It is visible that the eye-diagram has been closed, and a strong pattern-dependent effect is observed in the oscilloscope traces of the converted signal. The reason is that the recovery time of the SOA is over 100 ps, which is much larger than 25 ps (40 G bit-rate). We have also tuned the filter to select the red sideband of the probe light. The results are shown in Figure 4b. Again, a strong pattern-dependent effect is observed.

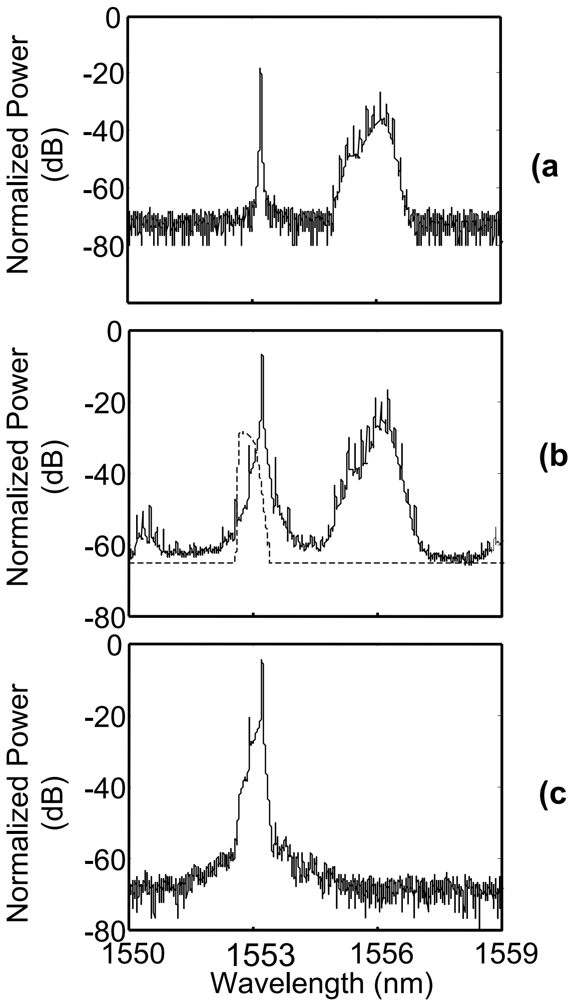
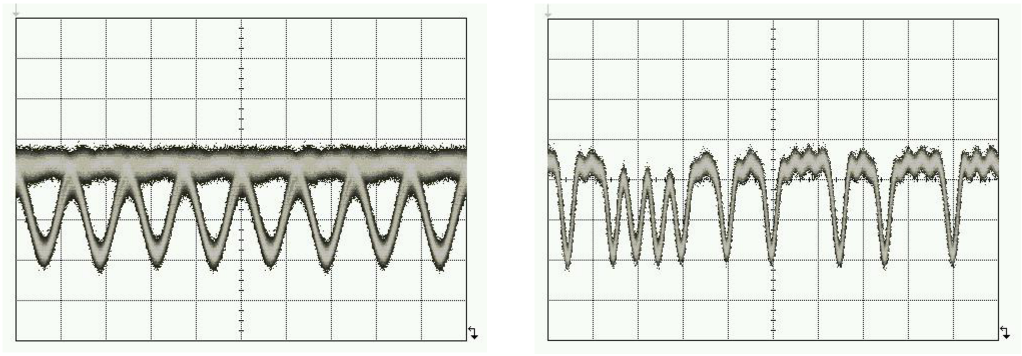


***Figure 2:*** *Optical spectra and the filter shape. (a) The optical spectrum at the input of the SOA. (b) The optical spectrum at the output of the SOA, the dashed-line shows the shape of the optical filter. (c) The spectrum after filtering the SOA output.*



**Time base: 20 ps/div** **Time base: 50 ps/div**

***Figure 3:*** *Experimental results of the converted 40 Gbit/s signal, when the blue shifted sideband is selected. Left: eye-diagram, Right: oscilloscope traces of the converted signal.*

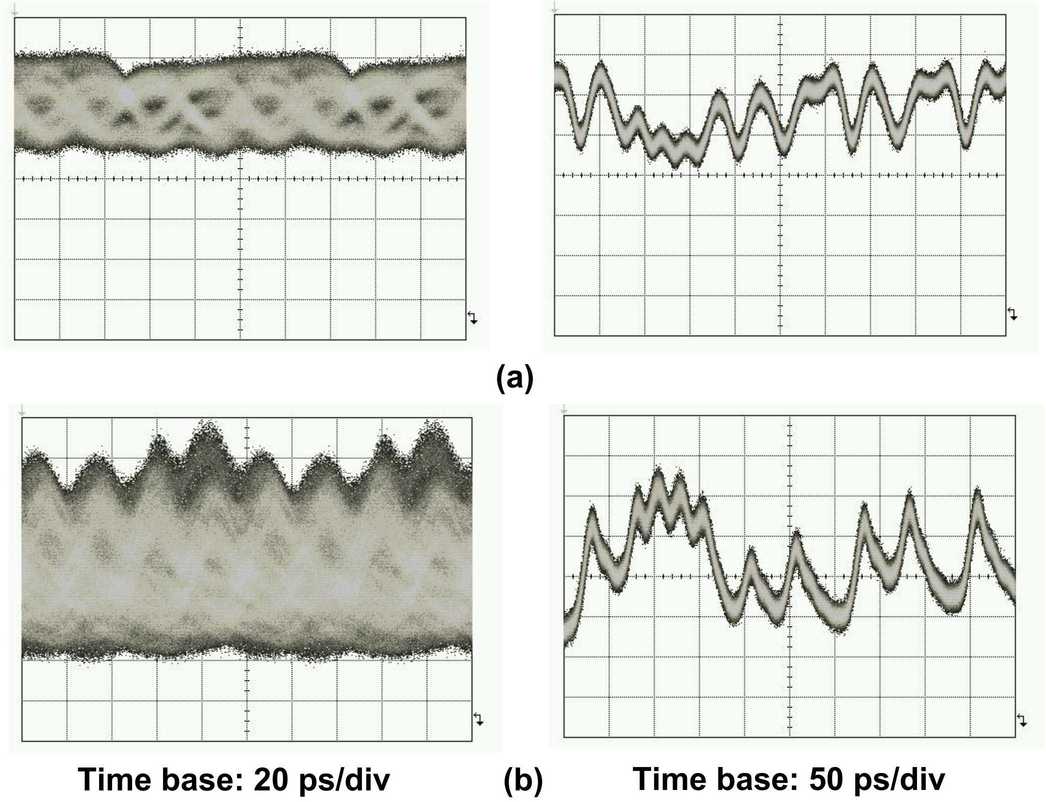


***Figure 4:*** *Experimental results of the converted 40 Gbit/s signal when (a) the peak of converted signal spectrum is selected, (b) the red sideband of the converted signal is selected. Left-column: eye-diagrams, right-column: oscilloscope traces of converted signal.*

## Conclusion

40 Gbit/s all-optical wavelength conversion has been demonstrated by using a narrow optical bandpass filter and an SOA that has a recovery time of more than 100 ps. A widely open eye-pattern of the inverted RZ signal at 40 Gbit/s has been obtained, which clearly shows that a narrow optical band pass filter can enhance the bandwidth of the SOA-based wavelength conversion.

## References

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