Towards terabit/s wavelength conversion with a single semiconductor optical amplifier and an optical bandpass filter

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Despite the relatively long carrier lifetime of a semiconductor optical amplifier (SOA), all-optical wavelength conversion based on a single SOA at 320 Gb/s has been achieved through a detuned filtering technique [1]. The function of the filter is to convert the probe chirp dynamics into amplitude modulation. Due to the ultra-fast chirp dynamics, this scheme is expected to work at much higher bit rates. In this work we numerically investigate the possibility of all-optical wavelength conversion at 1 Tb/s based on a single SOA and a Gaussian optical bandpass filter.

A comprehensive model [2] is employed to carry out the simulations for the carrier dynamics in an SOA. The ultra-short pulse propagation in an SOA is modeled through a nonlinear Schrödinger equation, which also accounts for gain dispersion and group velocity dispersion. The model has been used to simulate the gain recovery dynamics for 2 ps pulse with good agreement with experimental results [3]. In this work the input pump data is 2^7-1 pseudo-random binary series RZ signal. For every run 256 bits are propagated after an initial stabilization process for the SOA. The input pulses are Gaussian with a pulse width of 200 fs.

Fig.1 shows the output from a 12 nm (1.5 THz) Gaussian filter when it is tuned to the probe center frequency. In Fig.1(a), a eye diagram degradation induced by strong pattern effect is clearly shown. An ultra-fast gain recovery component induced by the ultra-fast carrier dynamics and followed by the slow gain recovery process is clearly visible [Fig.1(a)]. The ultra-fast carrier dynamics are known to enhance the XGM depth [4] and are instrumental for XGM based wavelength conversion. However, the closed eye diagram suggests a bad performance. The pattern effect is significantly reduced when the OBF is detuned to the shorter wavelength by 16 nm, as shown in Fig.2. The clear open eye diagram suggests the possibility for 1 Tb/s wavelength conversion. The probe power fully recovers during one bit [Fig.2(a)] and an open eye diagram is observed [Fig.2(b)]. The fluctuation reduction is more significant for the inverted '0' (lower power) level than the inverted '1' (higher power) level, consistent with the experiment [1]. In Fig.2, a stronger overshoot is observed at the leading edge of the (inverted) pulses than that at the trailing edge, as also shown in [1].

To quantify the performance of the output signal, a Q-factor is defined as the difference of the mean power (between the inverted '0' level and inverted '1' level) divided by the sum of standard deviations of both levels. Our results show that the Q-factor increases with filter detuning until a maximum is reached. With further increasing detuning, the output signal is distorted during the transition inverted to non-inverted. Higher probe power increases the Q-factor; however, eye opening decreases with too strong probe since the available gain is reduced due to more gain saturation. It also shows that larger detuning is needed for smaller pump pulse energy while too high pump pulse energy (e.g, 50 fJ) does not provide a larger Q-factor than smaller pump pulse (10 fJ).

In summary, extensive numerical simulations suggest that 1 Tb/s inverted wavelength conversion is possible with a single SOA and a detuned filter. Preliminary results show that, with the help of a delay-interferometer, non-inverted wavelength conversion at 1 Tb/s is also possible.

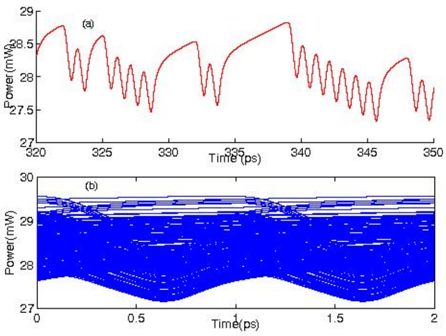

Fig.1 Waveform (a) and eye diagram (b) without filter detuning. The energy of the pump pulse is 10 fJ and the power of the probe is 5 mW.

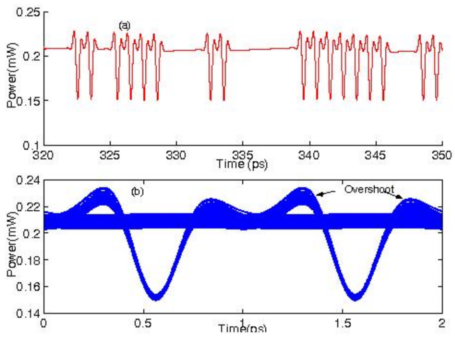

Fig.2 Waveform (a) and eye diagram (b) with 2 THz detuning. The energy of the pump pulse is 10 fJ and the power of the probe is 5 mW.

References:
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