Analysis of the Optimized Assist Beam for Semiconductor Optical Amplifier Based Four Wave Mixing Using Optisystem

Shreyashree Verma[1], Prof. A. K.Jaiswal[2], Er Mukesh Kumar[3]
[1] M.Tech (ECE), Deptt. Of ECE, SSET, Allahabad
[2] H O D, Deptt. Of ECE, SSET, Allahabad
[3]Assistant Professor, Deptt. Of ECE, SSET, Allahabad

ABSTRACT

The Conversion efficiency and the Optical Signal to Noise Ratio are the two Figure of Merits used to characterize the Four wave mixing process. They are used to study the impact of drive current, pump-signal detuning, input pump and signal powers on wavelength conversion process. In particular, the issue of optimum input pump and signal powers and range of assist beam is studied. We investigated the conversion efficiency (CE) and optical signal to noise ratio (OSNR) properties of ASE-assisted FWM in Semiconductor optical amplifier and demonstrated that in the presence of high internal Amplified Stimulated Emission, the requirement on input optical powers for wavelength conversion is reduced from 10s of mWs to less than 1 mW. As a proof of concept 10 Gb/s wavelength converter is demonstrated. While ASE-enhanced nonlinear effects in Semiconductor optical amplifier do relax the requirements on input signal powers, Various researchers studied that the wavelength converter by Four wave mixing effect in a semiconductor optical amplifier typically has poor efficiency but there is one more method to obtain high conversion efficiency is that to maximize the current of SOA, and one more thing various researches also showed that by applying assist beam the CE and SNR can be improved so in this paper we have assigned the various values for assist beam wavelength ranging from 1200 nm to 1600 nm and proved that 1480 nm is the best one.

Keywords - *Assist beam, FWM, SOA, WDM, Optical network, WC*

I. INTRODUCTION

All optical wavelength converters can be used in optical networks to solve the wavelength-blocking problems and provide wavelength routing and switching. There exist several wavelength conversion techniques using semiconductor optical amplifiers (SOAs), including cross-gain modulation, cross-phase modulation, and four-wave mixing (FWM).The conversion using the FWM effect has the merits of transparency to data rate and format and providing chirp compensation to the input signals. Though high conversion efficiency has been demonstrated with SOAs of very high gain the FWM conversion using typical SOAs generally suffers from poor efficiency and noise figure. Significant improvement on the conversion efficiency and noise figure is required for practical applications. The FWM conversion efficiency increases approximately with the unsaturated gain and the square of the saturation power of an SOA. Therefore, increasing the gain and/or saturation power of an SOA is essential to improve the conversion efficiency. The saturation intensity is inversely proportional to the carrier lifetime, so speeding up the carrier recovery rate of an SOA can enhance the conversion efficiency. Several research groups have proposed the schemes to change carrier dynamics and gain characteristics of an SOA by injecting an additional light, accompanying the signal light. The additional light is referred as an assisted light hereafter. The use of two parallel polarized pumps can increase efficiency to raise the FWM conversion efficiency in SOAs; an ultrafast relaxation-related gain process is dominant. Various researches resulted that applying the 1480 nm assist beam can improved the conversion efficiency and SNR. In this paper BER is investigated for various range of assist beam wavelength .It has also been verified that 1480 nm is the best wavelength to obtained CE and SNR, because at this wavelength we get minimum BER. Our main goals is to present a detail analysis of WC based on FWM. There is one more method to obtain the high CE and SNR i.e.; maximize the current of SOA without applying the assist beam. The value of CE and SNR are observed with low value of the input pump power and low detuning between Ps and P1 in presence of high current of SOA in the current work.

II. CONCEPT OF WAVELENGTH CONVERSION BASED SOA

All-optical wavelength conversion refers to the operation that consists of the transfer of the information carried in one wavelength channel to another wavelength channel in optical domain. It is a key requirement for optical networks, because it has basically to be used to extend the degree of freedom to the wavelength domain. Moreover, All-optical wavelength conversion is also indispensable in future optical packet switching (OPS) networks to optimize the network performance metrics, such as packet loss rate, packet delay, etc. Also, it is very useful in the implementation of switches in WDM networks. In addition, it is crucial to lower the access blocking probability and therefore increasing the utilization efficiency of the network resources in wavelength routed optical networks. While a significant part of network design, routing and wavelength assignment depends on the availability and performance of wavelength converters; and as many techniques have been explored and discussed in this context, all optical wavelength converters based on SOA structure have attracted a lot of interest thanks to their attractive features, such as the small size, the fast carrier dynamics, the multifunctional aspect and the high potential of integration. The main features of a wavelength converter include its transparency to bit rate and signal format, operation at moderate optical power levels, low electrical power consumption, small frequency chirp, cascadability of multiple stages of converters, and signal reshaping FWM effect in SOAs has been shown to be a promising method for wavelength conversion. It is attractive since it is independent of modulation format, capable of dispersion compensation and ultra fast. So, wavelength conversion based on FWM effect offers strict transparency, including modulation-format and bit-rate transparency, and is capable of multi-wavelength conversions. However, it has low conversion efficiency and needs careful control of the polarization of the input lights. The main drawbacks of wavelength conversion based on FWM are polarization sensitivity and the frequency-shift dependent conversion efficiency

III. EXPERIMENTAL SETUP

As depicted in fig 1experiment was perform using a set up similar to that used to measure the SOA converter by four wave mixing and assist beam[1]. The first pump beam (P1) is polarized parallel to the input signal (Ps), whereas, the second pump (P2) is orthogonally polarized. All Ps, P1, and P2 are combined and injected into an SOA with a small-signal gain of 23 dB. The input signal is modulated at 10 Gb/s using a $LiNbO_3$ modulator with a pseudorandom sequence. The signal wavelength is fixed at 1550 nm and its power is -12dBm. Two tunable lasers are used as P1 and P2 and their powers are set to -10 and –8dBm, respectively. Assist beam with a power of 23.6 dBm is contra-directionally injected into the SOA. A 1.48/1.55- m multiplexer is applied at the output end of the SOA to allow the injection of an assist beam and the output of the converted signal.

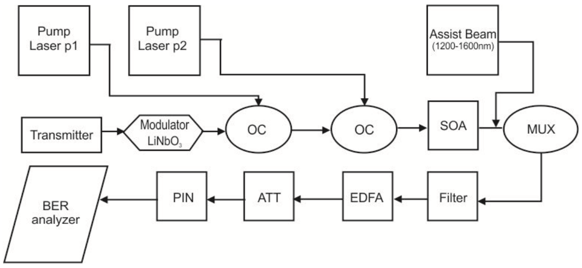


Fig 1: Block Diagram

Designed system has been simulated using simulation software Opti system software. Optisystem-10 is an advanced optical communication system simulation package designed for professional engineering. It can be used to design optical communication systems and simulate them to determine their performance given various component parameters. The CE and the OSNR are the two FOMs used to characterize the FWM process. They are used to study the impact of drive current, pump-signal detuning, input pump and signal powers on wavelength conversion process. In particular, the issue of optimum input pump and signal powers is analyzed in detail. The CE η and OSNR as a function of Δλ at the same two pump powers. As expected, both degrade as Δλ increases, indicating that one should not increase Δλ beyond an upper limit. Further, at any detuning, λ and OSNR are enhanced by more than 20 and 12 dB, respectively, when drive current is increased from 100 to 500 mA. This increase in λ and OSNR is observed for both pump powers. When two orthogonal pumps are used, the conversion efficiency is determined mainly by the FWM between Ps and P1.The FWM efficiency is proportional to the unsaturated gain and to the square of the saturation power of an SOA.

IV. RESULT AND DISCUSSION

The FWM conversion efficiency and SNR of the converted signal was measured by sweeping the wavelength of P2. The conversion efficiency is defined as the ratio of the converted signal power to the input signal power. The SNR is obtained by dividing the converted signal power by the noise power within 0.1 nm of optical bandwidth.

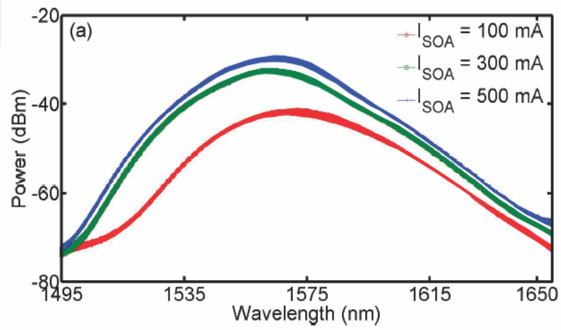


Fig2: Wavelength verses power with different bias current

An ASE spectra is plotted between wavelength and output power at 100,300and 500Ma bias current which is shown in fig2. The peak gain of the spectrum near 1570 nm shifts towards the blue side with increasing current. Moreover, a considerable increase in the amplitude of rapid oscillations near the peak gain at high drive currents is also observed. These oscillations have a period of 0.3 nm and have their origin in the residual feedback at the two SOA end facets, resulting in Fabry Perot effects. Finally this graph shows that, at a SOA bias current at 100Ma, we obtained the minimum power, then at 300mA power increases, but at the 500Ma, we obtained the maximum power. The blue one showing 500Ma SOA bias current is the better. So we take the highest value of I_{SOA} to obtain the maximum CE and SNR without applying the assist beam.

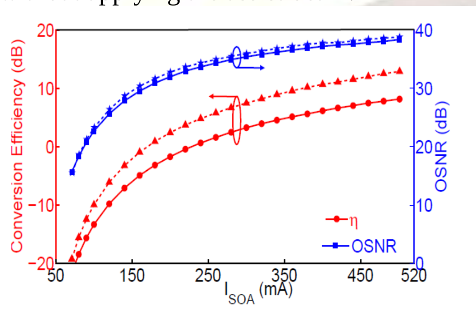


Fig3: Conversion efficiency and OSNR as a function of I_{SOA} for $\Delta\lambda = 0.5$ nm at a pump power of -3.3 dBm (dashed curves) and +3.3 dBm (solid curves). Input signal power was -10 dBm.

Efficiency and OSNR as a function of drive current for two different pump powers are plotted in fig3. As seen in the fig 3 OSNR actually increases with increasing current, indicating that the increase in the in-band ASE noise is more than compensated by the considerable increase in the idler power. An OSNR of > 30 dB along with a reasonable CE (η > 50%) can be achieved for ISOA > 160 mA. At a pump power of +3.3 dBm, decreases by about 4 dB because of pump-induced gain saturation, but the corresponding reduction in OSNR is much smaller (< 0.5 dB). This can be explained by noting that, while the idler power is reduced considerably at higher pump powers, the in-band ASE noise is also reduced because of pump-induced gain saturation.

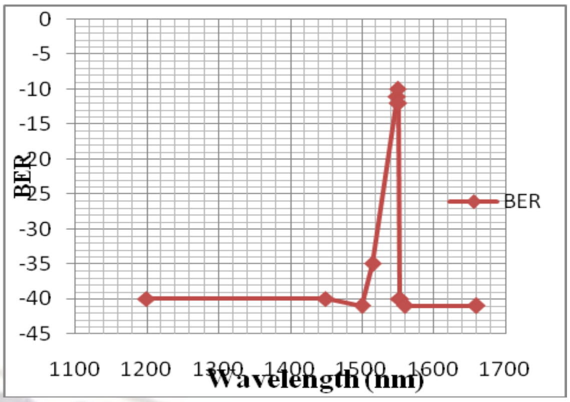


Fig5 : Graph plotted between wavelength and BER

A line graph is shown between wavelength and BER in fig5. The BER is measured at various wavelength of assisted beam. BER decreases as wavelength increases from 1200 to 1600nm. In the range of 1200nm to 1500 nm BER linearly decreases and attain a value of -40. Graph also show that wavelength of 1510nm is not advantages because at this wavelength, BER obtained high. Conclusion from this graph is that 1480nm wavelength is the best wavelength for using the range of assisted beam because it yields the minimum BER.

Received Eye pattern

(i) I_{SOA} = 300mA

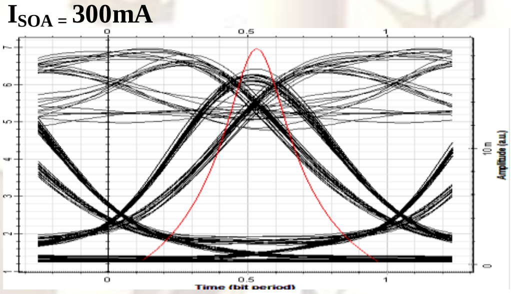


Fig6 : Received eye pattern at I_{SOA}=500Ma

This eye pattern diagram contains some error and having a low q factor ie; 20, as seen in fig6, which proves that at a current of 300 mA is also not suitable for obtaining the improved CE. so we can take the maximum bias current of SOA to improve the CE.

(ii) I_{SOA}= 500mA

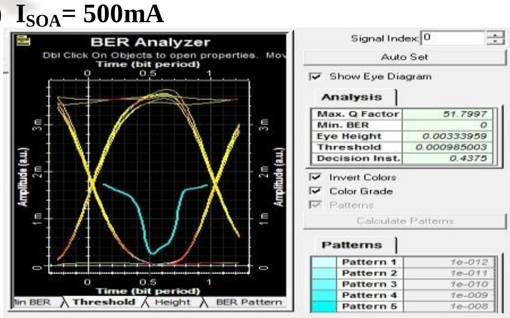
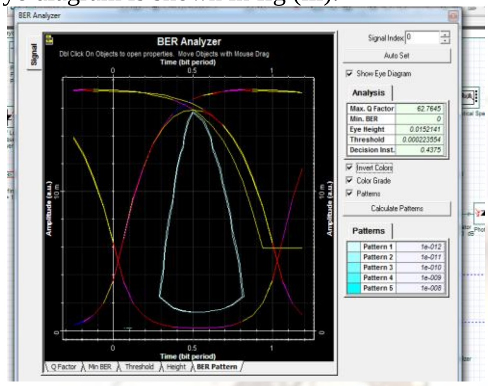


Fig7 : Received eye pattern at I_{SOA}=500mA

This pattern is much better than previous one, because in this case Q factor is increased upto a high value of 51. When Q factor is increases then BER reflects minimize. So we use this current $I_{SOA=}$ 500Ma to obtained the maximum CE.

(iii) Eye diagram at 1480nm wavelength of Assist beam

A eye diagram is shown in fig (iii).



From the above eye pattern diagram it is verified that 1480 nm wavelength of assist beam is the most optimum wavelength because maximum. Q Factor is obtained at this wavelength i.e.62

V. Conclusion

Conversion efficiency and OSNR are used as the two FOMs to characterize the wavelength conversion process. Both conversion efficiency and SNR improved, as the SOA current was increased from 100 to 500mA It is determined that the high conversion efficiencies over a broad range of input signal powers are possible even at pump powers as low as 0.1 mW. However, the OSNR of the converted signal at such pump levels may be below 25 dB because input signal power in this case must be considerably less than 0.1 mW. If the design criterion requires an OSNR of 30 dB or more, input signal power should be close to 0.1 mW, and this requires an input pump power close to 1 mW. CE and SNR are obtained high with increasing the SOA bias current .The wavelength of assist beam is also varied from 1200 to 1600 nm wavelength and BER is obtained. It was observed that any value for the assist beam can be taken except 1510nm and finally verified that wavelength of 1480nm is the best for the assist beam because of the minimum BER obtained at this wavelength.

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