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Demonstration of All-Optical Wavelength Converter Based on Fabry-Perot Semiconductor Optical Amplifier

Masumi Saitoh, Mitsuru Takenaka, Byongjin Ma, and Yoshiaki Nakano*

Department of Electronic Engineering, the University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan
Phone: +81-3-5841-6753, Facsimile: +81-3-5841-6027, e-mail: masumish@pc4.so-net.ne.jp

1. Introduction

All-optical wavelength converters are expected to increase the capacity and flexibility of WDM networks because they enable wavelength reuse and decentralized network management. Among a number of wavelength-conversion schemes investigated, cross-gain modulation (XGM) [1] and cross-phase modulation (XPM) [2] seem to be well suited for practical use at this stage. However, large input power required in XGM and active/passive integration process needed to realize XPM converters remain as shortcomings. In order to solve these problems, we have recently proposed a new scheme of all-optical wavelength conversion based on a Fabry-Perot semiconductor optical amplifier (FPSOA) [3]. In this paper, we report its static characteristics and demonstrate its polarity-inverted and polarity-non-inverted operation at 2.5Gbit/s.

2. FPSOA-based wavelength converter

A Fabry-Perot laser diode that is biased below threshold acts as an FPSOA. The gain spectrum of the FPSOA has resonant characteristics. Its strong sensitivity to frequency limits application of FPSOAs in optical communication systems. However, the FPSOA can be used as a multi-channel wavelength converter in WDM networks by adjusting the FP mode spacing to the WDM channel spacing.

First, we investigated gain characteristics of the FPSOA. Figure 1 shows measured gain of a 1.55μm InGaAsP/InP FPSOA as functions of the input power for different detunings from the initial FP resonance peak. At the upper right corner, detunings from the resonance peak (1522.63nm) divided by the FP mode spacing (0.52nm) are shown. The cavity length here was 500μm. In the case (a) where the wavelength of input light was set at the resonance peak, the gain decreased as the input power increased. This can be explained as follows; optical input causes the decrease of carrier density through stimulated emission and thus the increase of refractive index. Then, the gain spectrum of FPSOA shifts to the longer wavelength side. If the wavelength of input light is set at the resonance peak, the gain of input light decreases corresponding to the transition from resonance to non-resonance. This gain saturation occurs at much lower input power than in conventional XGM converters. On the contrary, abrupt increase of gain happens at about –5dBm input in the case (b) where the initial detuning of input light wavelength is 0.267 times the mode spacing on the longer wavelength side. This rapid increase corresponds to the transition into the resonance peak.

We applied these nonlinear gain characteristics in the FPSOA to all-optical wavelength conversion. We could easily realize wavelength conversion by injecting two lights; an intensity-modulated pump signal and a CW probe beam. In WDM networks, both the pump and the probe belong to the WDM channels. If we adjust the FP mode spacing to the WDM channel spacing, the difference between the pump wavelength and its nearest resonance peak wavelength is the same as that between the probe wavelength and its nearest peak. Therefore, the probe feels gain modulation caused by the pump, and data stream on the pump is copied onto the probe.

Figure 2 shows the measured characteristics of wavelength conversion. Output probe powers are plotted as functions of the input pump power for different detunings. Detunings from the resonance peaks were set to be identical for both pump and probe. The input probe power was -20dBm. In the cases where the wavelengths of input lights were set in the vicinity of the resonance peaks, inverted wavelength conversion happened. In contrast, non-inverted wavelength conversion happens within a certain input-power range in the cases where the wavelengths of input lights were detuned to the longer wavelength side of FP resonance peaks. It should be noted that wavelength conversion is achievable even with input pump power as low as –10dBm.

Figure 3 illustrates the experimental setup used for the measurement of dynamic characteristics. Figure 4 shows the measured inverted operation,

* Also with JST CREST.

where the wavelengths of input lights were set at the initial (i.e., without light injection) resonance peaks. The input pump signal is modulated with a 2.5Gbit/s pulse pattern. Figure 5 depicts the measured non-inverted operation at 2.5Gbit/s, where detunings were 0.31 times the FP mode spacing toward longer wavelength side.

3. Conclusion

We have proposed a new all-optical wavelength conversion scheme using a Fabry-Perot semiconductor optical amplifier (FPSOA). We measured its static characteristics and dynamic characteristics at 2.5Gbit/s. A 10Gbit/s operation of it is predicted in our preliminary numerical simulation. This scheme has many advantages such as ease of fabrication, sub-milliwatt control light power, and polarity-non-inverted operation. By adjusting the FP mode spacing to the WDM channel spacing, the FPSOA can be used as an inexpensive medium-speed multi-channel wavelength converter in WDM networks.

References

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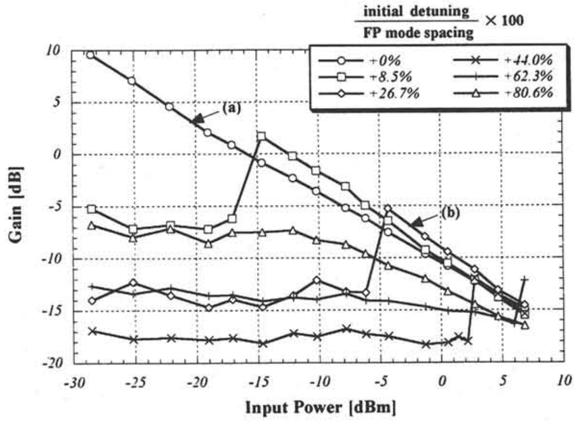

Figure 1 Measured gain characteristics of an FPSOA.

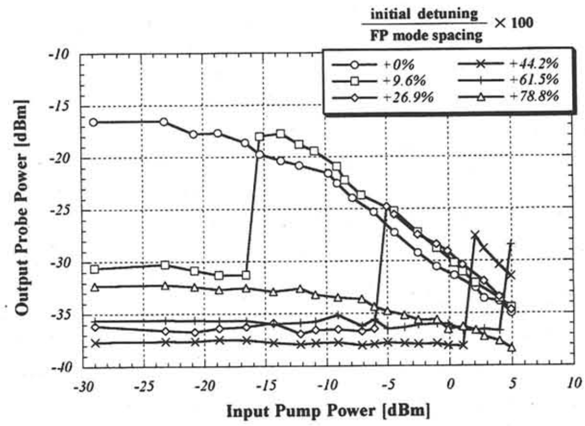

Figure 2 Measured wavelength conversion characteristics of the same FPSOA.

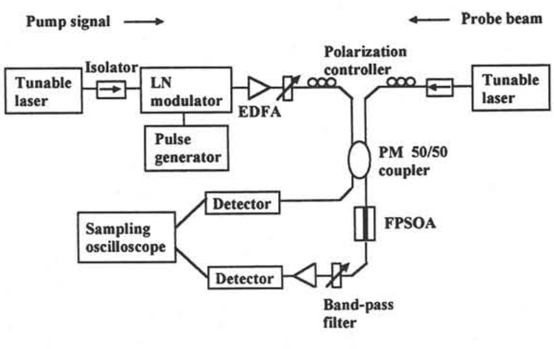

Figure 3 Experimental setup for dynamic characterization.

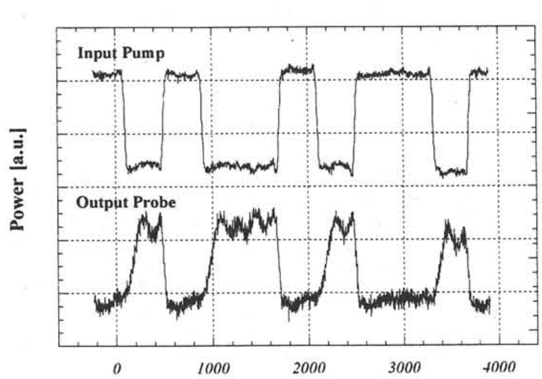

Figure 4 Inverted wavelength conversion operation at 2.5Gbit/s.

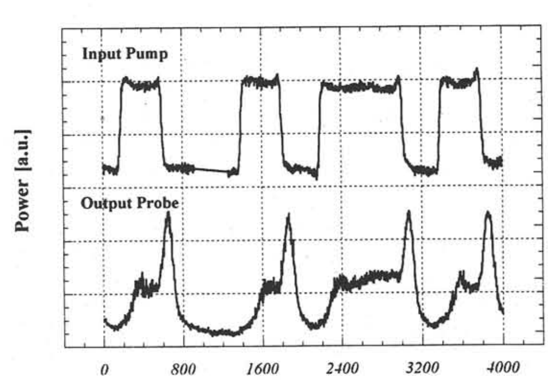

Figure 5 Non-inverted wavelength conversion operation at 2.5Gbit/s.