Polarization-independent Semiconductor Optical Amplifier

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Abstract: Semiconductor Optical amplifier (SOA) has received more and more attention, especially with the rapid development of the optical networks. In this paper the progress on the polarization-independent SOA and the wavelength conversion based SOA in our laboratory is described.

Keywords: semiconductor, optical amplifier, wavelength conversion

1. INTRODUCTION

The semiconductor optical amplifier has been developed since the early 80's. It was aimed at compensation for the fiber loss in the long-haul fiber communication system so as to increase the distance between repeaters. However during about first decade, the SOA with the bulk active material can not reach the performance requirements for the fiber transmission system; for example, low and polarization-dependent fiber-fiber gain (<20dB), high noise fiber (7~8dB), low saturation output (<10dBm), which are inferior to the Er+3 doped fiber amplifier (EDFA) developed in 1985.

However SOA has been pursued for its many outstanding advantages such as the compactness, low cost, integrated possibility with other semiconductor devices. In last decade, the strained quantum well material used as the active medium revived SOA. The performance mentioned above is significantly improved. Therefore, some of applications about SOA both the optical transmission and optical switching have been demonstrated in recent years. As an estimated schedule, SOA will be widely applied in the optical switching network in next few years. At the same time, it is possible for SOA to penetrate the fiber transmission system.

2. POLARIZATION-INDEPENDENT SOA

It is very important to obtain polarization-independent gain for the optical amplifiers. For SOA with the bulk active material, it exhibits a large polarization-dependent gain (ΔGTE-TM), because the mode confinement factor is larger for TE than TM. In addition, the recombination between electrons in the conductive band and heavy holes in the valent band dominates TE mode. In order to enhance TM mode gain, it is necessary to introduce the tensile strain into QWs. It is more difficult to make a SOA with the wavelength at 1.3μm windows than at 1.5μm windows, because of the conditions of both the possible compositions for In1-xGaxAs to match with InP substrate and the required wavelength (1.55μm) after A.R.Coating. Therefore we used a material structure which combines tensile-strained carriers and lattice matched well.

The radiative recombination takes place between electrons in well and light holes in barriers, as shown as Fig.1 [1].

With this structure, the polarization-insensible SOA has been realized in our group as shown in Fig.2. The best polarization-independent gain ΔGTE-TM is less than 1dB. At the same time, the strained MQW can make the other performance of SOA improve much, such as the fiber-fiber gain, noise figure, saturation output power and so on for its high differential gain. So far the fiber-

fiber gain and the saturation output are more than 15dB and 14dBm, respectively.

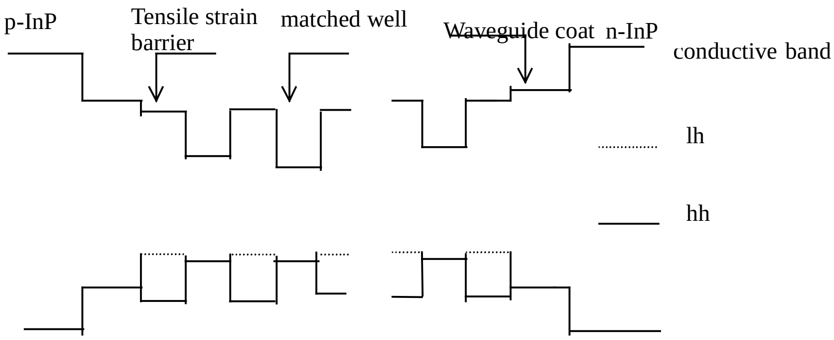
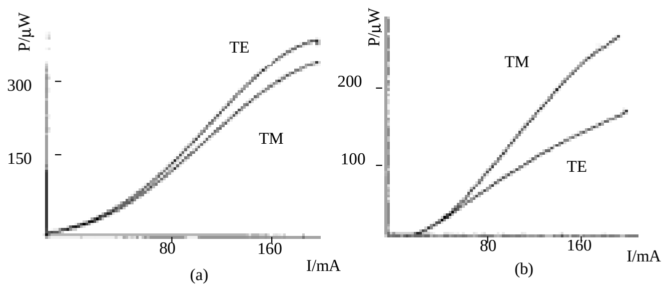


Fig.1 band diagram of a tensile strained MQW

3. WAVELENGTH CONVERSION BASED ON SOA

The wavelength converters or wavelength switchers will be very important devices in the future all-optical switching. There are methods to realize the wavelength conversion with SOA, such as the cross-gain modulation (XGM), cross-phase modulation (XPM) and four-wave-mixing (FWM). For the simplicity, the experiments of wavelength conversion with XGM in SOA have been achieved at the bitrate of 144Mb/s, 2.5Gb/s. The eye diagram of wavelength conversion at 2.5Gb/s is shown in Fig.3. The wavelength conversion span about 10nm with the extinction ratio of 8dB was achieved in our experiment. In order to achieve wavelength conversion with the high extinction ratio, SOA with high optical gain must be used and its saturation slope should be abrupt.



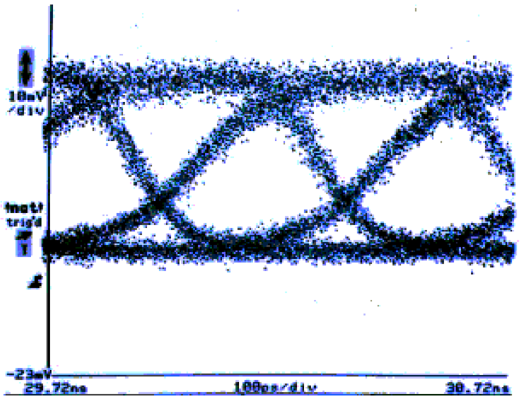


Fig.2 P-I characteristic curve of TE and TM mode after A.R.Coating (a) 1.3μm (b) 1.5μm

Fig.3 The eye diagram of wavelength conve-rsion at 2.5Gb/s

4. CONCLUSION

The polarization-independent SOA has been realized under cooperation with Wuhan Institute of Telecommunication. The wavelength conversion based on XGM of SOA at 2.5Gb/s also achieved.

REFERENCE

[1] Katsuaki Magari et al, Polarization-insensitive Optical amplifier with tensile-strained-barrier MQW structure, IEEE J. of Quantum Electronics, 1994, 30(3):695~701