Monolithic MZI All-Optical Switch with Selective Area MOVPE

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Introduction

Photonic integrated circuits (PICs) are playing more and more important roles in the optical fiber networks. Among various type PICs, hybrid ones [1] are disadvantageous in the size, stability and cost. Most monolithically integrated PICs [2] are based on low-yield etch and regrowth technique. Recently, regrowth-free bandgap engineering techniques are attracting more and more interest, including quantum-well intermixing (QWI) [3][4], and selective area growth (SAG) [5][6]. However, most of them are applied to simple laser-EAM integration [3][5].

Here we describe the realization of dynamic all-optical switching performance with SOA Mach-Zehnder interferometer (MZI) switch fabricated through wide-stripe selective area MOVPE.

Selective Area MOVPE for Monolithic Integration

Monolithic integration with selective area growth (SAG) technique is enabled by the Photoluminescence (PL) peak shift towards longer wavelength in SAG region. The first reason of the shift is the larger incorporation of indium than gallium, and the second is the lower quantum level in multi-quantum well (MQW) in SAG region, due to the thicker wells.

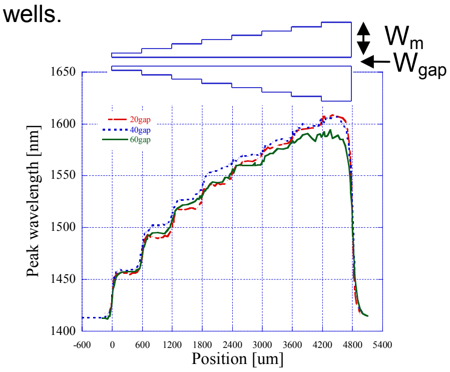

Fig.1 PL peak wavelength in SAG region.

The bandgap shift in SAG region relative to the planar region is dependent on the SAG mask width W_m, as depicted in Fig.1. The width of SAG region W_{gap} was 10μm, 20μm and 30μm, while mask width W_m was varied with 8 steps, from 0.5(leftmost) to 4(rightmost) times than that of W_{gap}. The PL peak shift was found to be decided by W_m / W_{gap} generally. For our device, we choose to use the planar region for passive components, and the SAG region with W_{gap}=20μm and W_{mask}= 50μm for active components (SOA).

Design and Fabrication of MZI All-Optical Switch

MZI all-optical switch, which can be operated with ultra-fast differential phase technique [7], was designed and fabricated. Microscope photograph of the switch is shown in Fig.2. All waveguides are ridge type, formed by wet chemical etching. The length of the SOA-SAGs is 1mm, and the total length of the switch is 5.5mm.

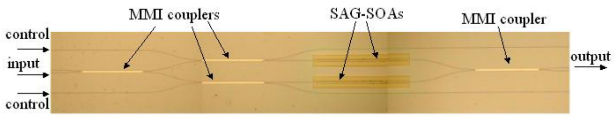

Fig.2 Fabricated MZI SOA all-optical switch.

Dynamic All-Optical Switching

Shown in Fig.3 is the all-optical switching output. The broad peak is the output when only one path control light was coupled into the switch. On the other hand, the narrow peak is the result when both path control pulses were coupled into the switch with a time delay, i.e., with differential phase technique. The sharp output pulse width was the direct reflection of the switching window of 28ps.

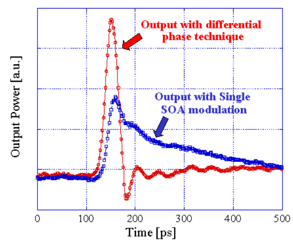

Fig.3 28ps switching window with two SOAs differential phase technique (narrow peak). Single SOA modulation reveals carrier recovery time of the SOA of several hundred picoseconds (broad peak).

Conclusions

We have demonstrated a bandgap-engineered dynamic monolithic MZI SOA all-optical switch, with wide stripe selective area MOVPE. In all-optical switching under differential phase technique, a 28ps switching window was successfully achieved.

References

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