All-Optical Processing Using Cross-Phase Modulation in Semiconductor Quantum Heterostructures

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Mach-Zehnder interferometers employing semiconductor quantum heterostructures as nonliner media (Fig. 1) are quite versatile because they can be applied for all-optical processing such as all-optical switching, wavelength conversion, and add-drop multiplexing. We have been investigating the following two approaches toward all-optical processing.

SOA-based Mach-Zehnder Interferometer

InGaAsP MQW semiconductor-optical-amplifier (SOA)-based Mach-Zehnder interferometer was fabricated by single-step metal-organic vapor phase epitaxy (MOVPE) selective area growth (SAG) [1,2]. This technique brought about wavelength shift as large as 140nm between passive and active region. The fabricated device showed very large phase shift more than 10π by injecting current up to 120mA. Preliminary all-optical-switching experiment was also performed; total phase shift of 0.5π was realized under control power of +15dBm.

EAM-based Mach-Zehnder Interferometer

MQW electroabsorption-modulator (EAM)-based Mach-Zehnder interferometer [3] is also very attractive because high-speed operation more than 40Gbps and requirement of small signal power is expected. Theoretical calculation reveled that in InGaAlAs MQW-EAM photo-induced phase shift of π is achievable under relatively small signal power of +6dBm and that the enlargement of extinction ratio is possible (Fig. 2). In compressive-strained InGaAsP MQW-EAM wavelength conversion was experimentally demonstrated; the required signal power was less than +8dBm (coupling loss around 6dB is included) and enlargement of extinction ratio from 10dB (signal light) to 23dB (converted light) was realized.

Further reduction of control power in SOA-based Mach-Zehnder interferometer and the demonstration of high-speed operation are subjects for future studies.

References

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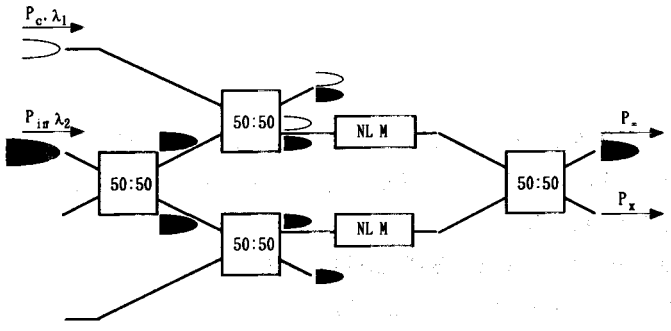

Fig.1 Schematic of Mach-Zehnder interferometer employing semiconductor quantum heterostructures.

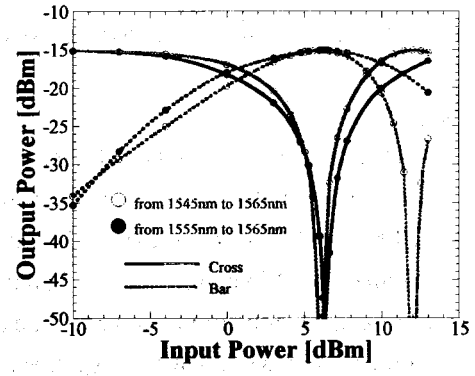

Fig.2 Wavelength conversion characteristics of InGaAlAs MQW-EAM Mach-Zehnder interferometer