Experimental investigation of QCSE-based Stokes vector modulator on InP

量子閉じ込めシュタルク効果を用いた InP ストークスベクトル変調器の試作と実証

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Stokes vector modulation (SVM) is gaining increasing interest for data center networks and short-reach communication links. This is mainly driven by demand in improving the power and spectral efficiencies of current low-cost direct-detection (DD) formats without introducing expensive coherent optical technologies. Lately, various types of transmitters in photonic integrated circuits for SVM have been demonstrated [1-2]. Here, we experimentally investigate a SV modulator on InP using quantum-confined Stark effect (QCSE).

Fig.1 shows the schematic of the device, which consists of a pair of passive polarization converter (PC) and an active multiple-quantum-well (MQW) based polarization-dependent phase modulator (PD-PM) sections, concatenated in series. The PC sections is designed to operate as a quarter wave plate with its principal axes tilted by 45° with respect to the substrate, while the PD-PM is electrically driven to convert input TE or TM polarization state to arbitrary state on the Poincare sphere [1]. Unlike our previous devices [1,3], QCSE in a 0.4% compressively strained InGaAsP/ InGaAsP MQW is used to enhance the polarization dependence of the refractive index change under a reverse bias, thus allowing potentially high-speed and efficient polarization modulation.

The device was fabricated by offset quantum-well scheme using single metal-organic chemical vapor deposition (MOCVD) regrowth step. After selective removal of MQW layers from the passive part, p-InP cladding and p-InGaAs layers were grown. Then, self-aligned process is employed to define the PC, PD-PM and the passive waveguides [3].

Fig. 2 depicts the polarization-dependence of optical absorption spectra, measured for a single

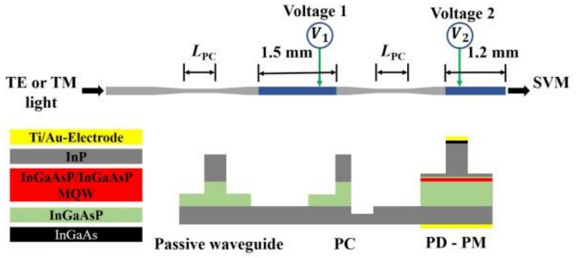

Fig. 1. Schematic of integrated Stokes vector modulator.

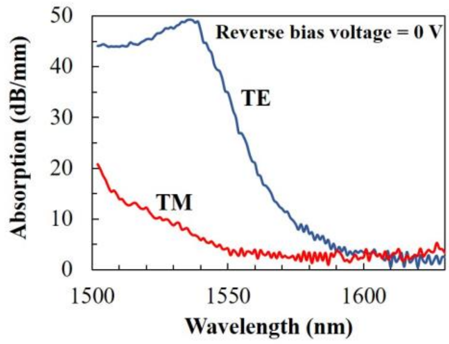

Fig. 2. Absorption spectra of PD-PM section for TE and TM light.

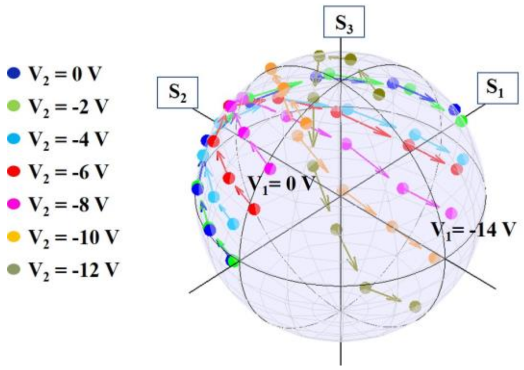

Fig. 3. SOP modulation for incident TM light at 1610nm.

750 µm long PD-PM waveguide. Excitonic peak at 1540 nm wavelength for TE mode proves the presence of large polarization-dependent absorption in the strained MQW layer. From Fig. 2, we set the operating wavelength to be 1610 nm, where the material is nearly transparent but light experiences large polarization-dependent refractive-index change upon external bias. At this wavelength, we obtain $V_\pi L$ of 2.1 V·cm and PDL of 3.5 dB at V_π. Fig. 3 shows the state of polarization (SOP) modulation when we vary both V_1 and V_2 for TM incident light. We can confirm that the SV rotates in nearly orthogonal directions for respective PD-PMs, in agreement with theory. We expect further improvement in modulation efficiency and reduction of PDL by optimizing MQW design and waveguide structure at PD-PM.

Acknowledgement

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Reference

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