Extended Abstracts of the 21st Conference on Solid State Devices and Materials, Tokyo, 1989, pp. 549-550



# 5:1 On-Off Contrast InGaAs/InP Multiple Quantum Well Fabry-Perot Etalon Modulator

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Abstract

Semiconductor optical modulators with a surface-normal incident configuration are very important for parallel high bit-rate signal processing. A promising approach to obtain high contrast modulation is to use a Fabry-Perot (FP) etalon configuration. Recently, high ON-OFF contrast GaAs/AlGaAs multiple quantum well (MQW) etalon modulators have been reported [1],[2]. There has been, however, no report on etalon modulators using an InGaAs/InP MQW, which are suitable for 1.55 $\mu$m wavelength light modulation in optical communication systems. Moreover, the refractive index change near the exciton resonance in InGaAs/InP MQWs has not been directly observed. We demonstrate an InGaAs/InP MQW etalon modulator operated at 1540 nm for the first time.

Figure 1 shows a cross section of the device structure. The semiconductor layers were grown by low pressure (80 torr) metalorganic vapor phase epitaxy. The MQW consists of 40 periods of alternate 8 nm thick $i$-InGaAs wells and 10 nm thick $i$-InP barriers. Selective Zn diffusion forms a $p^+$-region in the top of the InP layer and completes the $p$-$i$-$n$ diode structure. Dielectric mirrors were deposited by the electron cyclotron resonance chemical vapor deposition and form a FP etalon. The dielectric mirrors consist 4 periods of alternate 287 nm thick $SiO_2$ layers and 141 nm thick amorphous Si layers. The dielectric mirror reflectivity was 97.8 % at 1550 nm and was more than 96 % in the range from 1450 nm to 1850 nm.

Figure 2 shows the MQW etalon transmission spectra observed at several applied voltages. A FP resonant peak around 1540 nm shifts and disappears as the applied voltage increases. The ON-OFF contrast reaches 5:1 for an applied voltage of -16 V at 1540 nm. We estimate the refractive index changes from resonant peak shift and the absorption coefficient from the FP contrast ratio. Figure 3 shows the relative refractive index change $\Delta n/\tilde{n}$ and absorption coefficient as a function of applied voltage. The maximum relative refractive index change is -0.9 % at -16 V. The absorption coefficient increases from 1000 $cm^{-1}$ to 6300 $cm^{-1}$ as the bias voltage increases from 0 V to -16 V.

We have obtained 5:1 ON-OFF contrast in InGaAs/InP MQW etalon modulator at the -16 V applied voltage. This is the first demonstration in 1.55 $\mu$m wavelength region. The InGaAs/InP MQW etalon modulator is promising for parallel high bit-rate signal processing in optical fiber communication systems.

We would like to thank M. Sakaguchi and T. Suzuki for their encouragement, S. Matsumoto and K. Komatsu for helpful discussions.

References
[1] R.J. Simes, et al, Appl. Phys. Lett., 53, (1988) 637.
[2] Y.H. Lee, et al, Appl. Phys. Lett., 53, (1988) 1684.

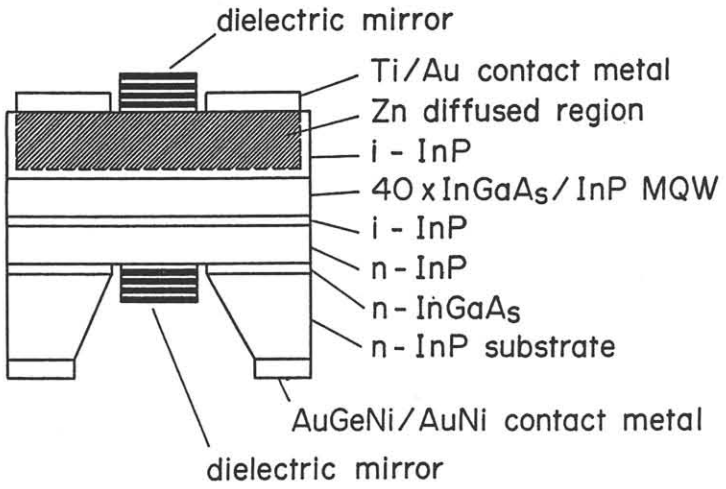


Fig. 1. A cross sectional view of the MQW etalon modulator.

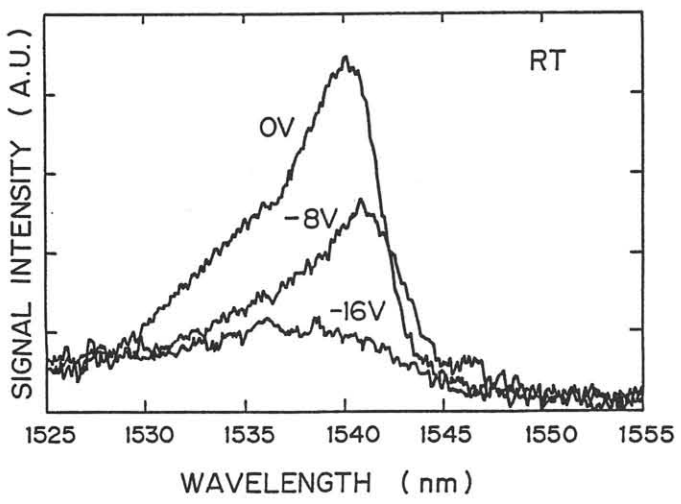


Fig. 2. Transmission spectra for the MQW etalon modulator with several applied voltages.

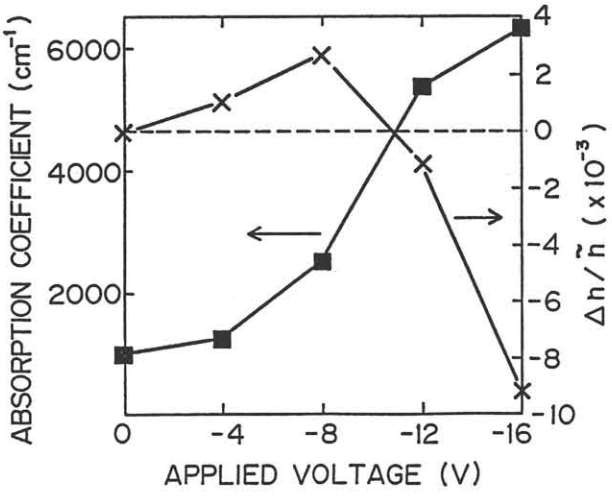


Fig. 3. Absorption coefficient (squares) and relative refractive index change (crosses) as a function of applied voltage.