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# Electric-Field Dependent Optical Absorption in an InAlAs/InP Type II Superlattice

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The InAlAs/InP superlattice has staggered band alignment called a *Type II* structure. This structure is created by the Γ valleys in both layers as shown in Fig. 1 (a). Few works have been reported on the optical properties of this superlattice (SL) [1], and no reports of electro-absorption in Type II SLs has been published. In this paper, we show the change in optical absorption when an electric field is applied to the Type II SL at room temperature.

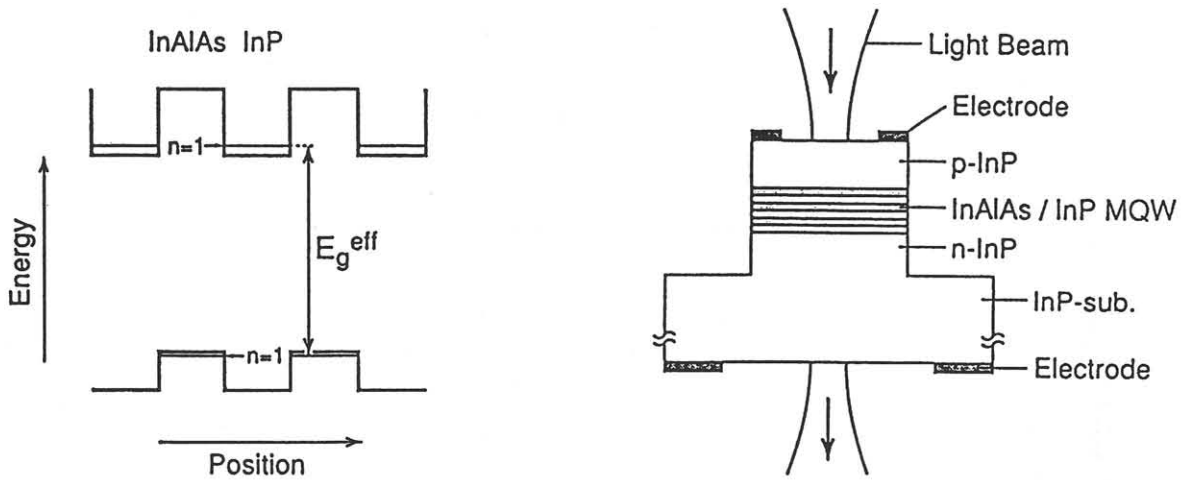
The SL layer consists 40 periods of 7-nm-thick InAlAs and 6.5-nm-thick InP layers. The effective band gap $E_g^{eff}$, shown in Fig. 1 (a), which is the energy difference between the first quantum level in the InP conduction band and that in the InAlAs valence band is estimated to be 1.16 eV (1069 nm). The sample structure for optical absorption measurement is shown in Fig. 1 (b). The undoped SL layer and adjoining $n$- and $p$- doped InP layers were grown on an $n$-InP substrate by Gas Source Molecular Beam Epitaxy. Circular electrodes were attached to apply the electric field and to transmit optical beam.

In absorption measurements, monochromated light from a halogen lamp was used as probe light, and it was detected using a photomultiplier. The transmissivity of the sample corrected by comparing the sample and a 210-$\mu$m-thick InP is shown in Fig. 2 (a) together with the wavelength for the $E_g^{eff}$. Although a moderate etalon effect is observed at wavelengths longer than 970 nm, there is no clear (excitonic) absorption structure in the region. This result shows the characteristics of the SL where the optical absorption around $E_g^{eff}$ is an indirect transition.

When electric field was applied, the optical absorption changed in the 1-$\mu$m-wavelength region, as shown in Fig. 2 (b). The change increased as the reverse bias voltage increased and it reached 150 $cm^{-1}$ at 8 V which corresponds to an electric field of 148 kV/cm. This absorption increase is due to the increase in the overlapping of wavefunctions in InAlAs and InP layers that occurs with the electric-field application. The other absorption increase observed at wavelengths shorter than 970 nm with the voltage greater than 6 V is considered to be the Franz-Keldysh effect in InP layers.

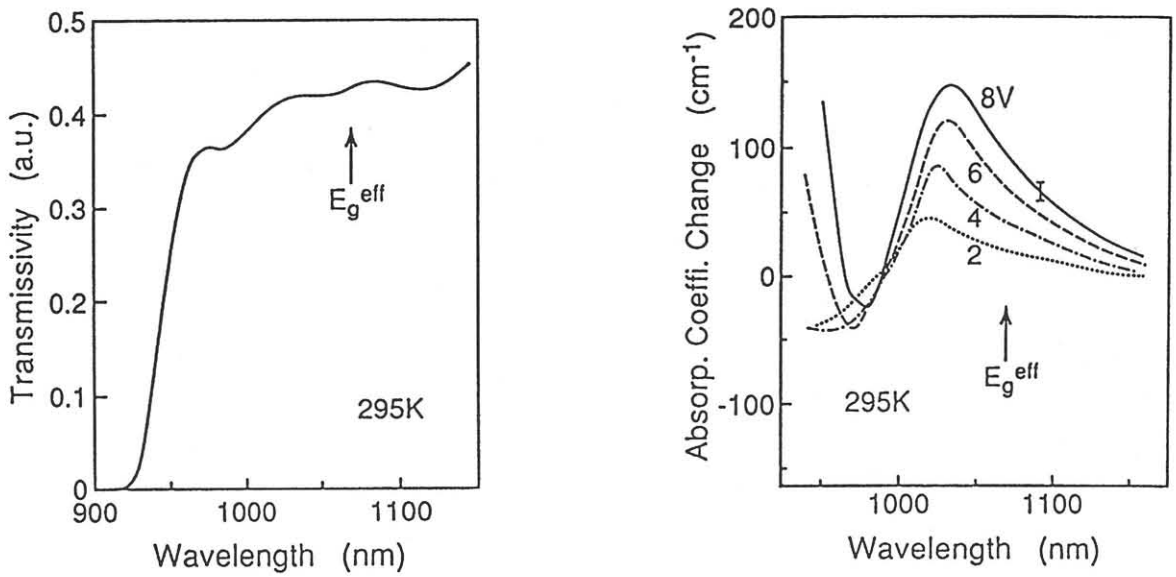
In conclusion, we have observed electro-absorption in Type II SL for the first time. The InAlAs/InP SL can be applied to a modulator, especially for the many solid state lasers that operate around 1 $\mu$m.

[1] *E. Lugagne-Delpon et al., Workbook of 5th. Int. Conf. Modulated Semiconductor Structures, PC-17, p.520, Nara Japan (1991).*




(a) (b)

Fig. 1 Energy band structure of InAlAs/InP Type II (staggered) Superlattice (a), and $p-i-n$ structure to measure electro-absorption (b).




(a) (b)

Fig. 2 Transmissivity of the sample (a), and change in optical absorption coefficient under bias application (b).