Improved Performance of MQW Amplitude Modulators by the Introduction of a Delta-doping Superlattice

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Recent demands for multiterabit communication require external optical modulators operating at low voltages. Amplitude modulators based on the Quantum Confined Stark Effect in III-V semiconductors multiple quantum well (MQW) systems are suitable for meeting these technological demands and therefore, much attention has been devoted to the development of such modulators. One of the crucial requirements for efficient modulation at high bit rates is that the change in absorption per applied voltage be as large as possible. In other words, the Stark shift should be maximized. The larger the quantum well is, the larger the Stark shift. However, increasing the quantum well width decreases the oscillator strength for absorption. Thus, a compromise is imposed. An alternative for increasing the Stark shift has been proposed by Batty and Allsopp [1]. They have theoretically shown that the introduction of a \text{np}i delta-doping superlattice in a GaAs/AlGaAs MQW structure, where the quantum well is \text{n} delta-doped while the barrier is \text{p} delta-doped, may double the Stark shift.

For application in long distance communication, the InGaAs/InAlAs system is preferable since it can operate at 1.55 \mu m, it can be grown on InP substrates and in addition it has a smaller valence band offset, avoiding premature saturation effects. Simulation of the performance of amplitude modulators based on InGaAs/InAlAs multiple quantum wells (MQW) containing a \text{np}i delta-doping superlattice is carried out. Device parameters such as contrast ratio, insertion loss and chirp parameter are determined from the calculated absorption curves. It is found that for this system, contrary to the case where the MQW structure is undoped [2], it is possible to simultaneously obtain devices that are polarization insensitive and have a chirp parameter between 0 and -1 to compensate for the fiber dispersion. Finally, the critical role, played by the QW alloy composition, is addressed. It is shown that the device performance may deteriorate with the introduction of a delta-doping superlattice for values of Ga content in the QW alloy which are within certain intervals.