(1) Field-driven all-optical wavelength converter using novel InGaAsP/InAlGaAs quantum wells

Once the pump light is absorbed in QW region, XAM can be operated by blue shift of QW

from the generated photocarriers, such as charge screening, band filled effect, or exciton

bleaching. The probe light can thus be modulated through QCSE of QW. Therefore, the speed

limitation based on XAM in QW will be mostly relied on carrier sweep-out behavior. High

sweep rate of photocarrier can set up high screening electric field to drive probe light by

QCSE, where three major processing are thermion emission, recombination, and tunneling

processing. When the QW device is operated under high reverse bias, due to the low overlap

in electron- and hole- wave functions, the probability of recombination can be neglected.

Also, by comparing with field-enhanced tunneling processing, thermal emission effect can be

neglected due to lower statistical distribution of hot carrier. Hence, the swept-out rate by

tunneling processing out of multiple QWs (MQWs) is assumed as the main operation

mechanism to recover absorbing state after high pump power excitation [15,16]. Considering

a single quantum well case, carrier swept time (Tτ ) through tunneling processing can be

represented by Eq. (1) [17-18]:

is the band gap difference between well and barrier. cE and vE are band offsets of conduction and valence band respectively. Lw and Lb are widths of quantum well and barrier, where the effective mass is denoted as mi and mbi (i = e or h are for electron or hole), and ( ) ( ) n iE is the n th sub-band energy level. F is the electric field in well. Although high external electric field could fasten carrier tunneling processing, conduction electron confinement will then be reduced to deteriorate QCSE. Therefore, band offset ratio and carrier effective mass of conduction and valance bands are main design issues for overall all optical performance. In general semiconductors of bandgaps λ = 1300nm or 1500nm, effective mass of valance-band heavy hole (~0.1 mo) is around one order of magnitude larger than conduction-band electron.

Heavy-hole dynamics is thus the key issue responsible for slow carrier sweep rate. Although valance band offset (vE ) could be reduced through band gap engineering, the lowered conduction band offset (cE ) will inevitably reduce optical modulation efficiency due to reduced QCSE by light conduction-band electron mass. Therefore, as a point view of material design, large band offset ratio ( /c vE E ) becomes one of the main parameters to get high-speed efficiency AOWC. Large /c vE E could have advantages of allowing high applied electric field to fasten carrier processing while still maintaining significant QCSE [18,19].