FEMTOSECOND CARRIER DYNAMICS IN InGaAsN SINGLE QUANTUM WELL

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Abstract -- *Femtosecond carrier dynamics in InGaAsN single quantum well were studied for the first time. Pump-probe measurement shows the enhanced free carrier absorption due to highly excited carriers with a delayed carrier cooling time around 2~3.7 ps.*
OCIS codes: (160.6000) Semiconductors, including MQW, (320.7120) Ultrafast phenomena.

We investigated the femtosecond carrier dynamics in InGaAsN/GaAs single quantum well by pump-probe techniques. Two different samples grown with MBE on the n-type GaAs substrate are studied. One has a 6-nm $In_{0.3}Ga_{0.7}AsN$ well sandwiched by 120-nm GaAs barriers, while the other inserted 5-nm GaAsN strain-meditating layers between the well and the GaAs layers at both sides. The nitrogen content of InGaAsN and GaAsN are both 2%. According to the PL measurements, the insertion of GaAsN layer makes the bandgap energy red-shifted from 1270 nm to 1330 nm. In our pump-probe measurement setup, the optical pulses were from a mode-locked Cr:forsterite laser operating around 1230 nm. Their pulse width and bandwidth were 130 fs and 16 nm, respectively. Figure 1 shows the differential transmission trace for the 1270 nm sample (without GaAsN meditating layers) of a high pump fluence of 1.5 mJ/cm^2. It exhibits a dip at zero time delay followed by a positive exponential decay with a negative step. The dip is attributed to two-photon absorption (TPA) in both the quantum well and the surrounding GaAs layers. After a deconvolution procedure (dotted curve), we found a 2 ps relaxation time constant for the positive exponential decay component. The negative step is attributed to the enhanced free carrier absorption induced by a large number of photoexcited carriers by the pump pulse [1]. We exclude the bandgap renormalization effect from the cause of the negative step because of the fact that the probe energy (1eV) is higher than the bandgap energy (0.98 eV). The differential transmission trace for the 1330 nm sample (with even narrower bandgap energy 0.93 eV) with the same pump fluence still shows a negative step (Fig. 2, solid curve). This observation also confirmed that the observed negative step is due to the free carrier absorption. By the same deconvolution procedure (Fig. 2, dotted curve), we found a slightly longer relaxation time (~3.7 ps) for the positive exponential decay component of the 1330 nm sample. The relatively long 2~3.7 ps delayed carrier cooling time can be attributed to the enhanced free carrier absorption [2].

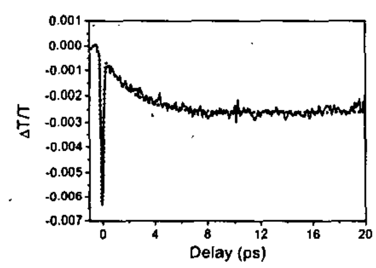

Fig. 1. Transmission pump-probe trace (solid curve) and its fitting curve (dotted curve) of InGaAsN sample without GaAsN strain-meditating layers.

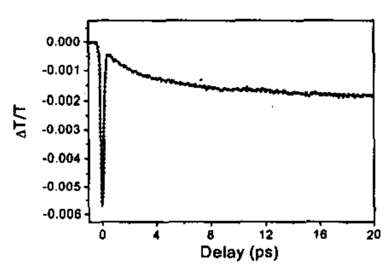

Fig. 2. Transmission pump-probe trace (solid curve) and its fitting curve (dotted curve) of InGaAsN sample with GaAsN strain-meditating layers.

[1] G. A. Khodaparast *et al.*, "Terahertz Dynamics of Photo-generated Carriers in Ferromagnetic InGaMnAs," accepted for publication in *J. Appl. Phys.* (2003)

[2] M. Joschko *et al.*, "Ultrafast hot-carrier dynamics in semiconductor saturable absorber mirrors," *Appl. Phys. Lett.* **76**, 1383-1385 (2000).

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