Low temperature magnetoresistance of strongly coupled superlattices

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We report the observation of an increase in magnetoresistance in a strongly coupled superlattice associated with the transition to the quantum box (1-D) conductance regime. The system studied consists of 100 period superlattices made using the type II system InAs/GaSb which allows superlattices to be constructed with relatively wide minibands using quite thick and well controlled layers. The strong interband coupling gives rise to lowest miniband widths (Δ) of 32 and 24meV in structures with GaSb barriers of 5 and 7nm respectively, but with a strong reduction in miniband width for higher states.

In the experiment I-V and Resistivity traces show a well-defined threshold voltage for superlattice conduction which increases slowly to higher biases when a magnetic field is applied. At very high fields, above 16 Tesla, the Resistivity and I-V traces are dominated by the magnetic freeze-out of carriers within the InAs substrate. Prior to this, traces are dominated by superlattice transport phenomenon, which include Stark cyclotron resonance and the magnetophonon effect.

Upon reaching the condition that the miniband width is greater than the Landau level spacing $\Delta > \hbar\omega_c$ an increase in resistivity is observed. At this point the system enters a new regime of transport in which the overlap between adjacent Landau levels due to miniband formation is removed and the system can be thought of as a true 1-D or quantum box superlattice. The rapid increase in resistivity at fields above this point is attributed to the strong suppression of elastic interLandau level scattering[1]. Within the quantum box transport regime the threshold voltage is seen to increase rapidly with field. The magnetoresistance is also found to strongly **increase** at higher bias voltages in contrast to most normal magnetoresistance phenomena. These two effects are attributed to the large changes in superlattice transport which occur at the transition to quantum box transport. At this point the suppression of elastic scattering dramatically reduces the current in the high field limit due to the increased probability of Bloch transport.

This qualitative picture is strongly supported by Monte Carlo calculations which include acoustic and optic phonon scattering as well as Umklapp processes. These show that there are large oscillations in the conductivity as the successive Landau levels become un-nested and at the transition to quantum box transport there is a large magnetoresistance which is strongly enhanced at high bias voltages.

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[1] Murphy et. al. Physica B, 256-258, (1998) 544-547.