Nonlinear transport and inverted magneto-intersubband oscillations in a triple quantum wells

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A two-dimensional (2D) electron system in a perpendicular magnetic field shows magnetoresistance oscillations, known as Shubnikov-de Haas oscillations (SdH) originating from the sequential passage of the Fermi level through Landau levels. If more than one subband is occupied the possibility of intersubband transitions start to occur and leads to another kind of magnetoresistance oscillation. These oscillations, called magneto-intersubband oscillations (MIS) have been studied in single quantum wells with two occupied subbands [1] and recently in a double quantum well (DQW) system [2] and triple quantum wells [3]. MIS oscillations offer new possibilities in transport measurements, e.g. the determination of quantum lifetimes in regions where SdH oscillations are completely suppressed at high temperatures [2, 3]. The nonlinear transport in two-dimensional 2D electron systems placed in a perpendicular magnetic field has been extensively studied in the past in connection with the Hall-field induced resistance oscillations (HIROs) [4] and zero differential resistance state phenomena [5]. Recently novel nonlinear effects in DQW have been observed: with increasing current I, the amplitudes of the MIS oscillations decrease, until a flip of the MIS oscillation picture occurs.

In present paper we study the inverted MIS oscillations in TQW systems. A triple quantum well system consists of three quantum wells separated by thin barriers where electrons occupy three 2D subbands coupled by tunneling. Our samples are coupled GaAs triple quantum wells (TQWs) with a central well width of 20 nm and lateral well widths of 14 nm separated by a 1.4 nm barrier in a 2D electron gas with a mobility of 5×10^5 Cm^2/Vs.

The barrier widths are 1.4 nm and 2 nm, respectively. In our experiments, we have found that the current induced inversion of the magnetoresistance shows up in TQWs as a flip of the MIS oscillation pattern. We determine the critical magnetic field corresponding to the inversion of the quantum contribution to resistance for 3 different periods of MIS oscillations. Moreover, we compared the measurements for macroscopic size (500 μm) and mesoscopic size (5 μm) samples and found essential difference in the nonlinear transport behavior.

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