Effective Mass Suppression in Fully Spin-polarized 2D Electron System

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Introduction

Effective mass of carriers confined to two dimensional (2D) systems is a quantity of fundamental interest. Analysis of the temperature dependence of Shubnikov-de Haas oscillations has been used to experimentally determine this parameter. Previous studies have shown an increase in effective mass (m*) as the density of the 2D system is reduced and the system is made more interacting. Most of these studies have concentrated on the partially spin-polarized regime.

Experimental

We performed magnetotransport measurements on a 2D electron system confined to a 15 nm-wide AlAs quantum well with tunable density using the 18/20 T DC magnet of the NHMFL millikelvin facility using standard low-frequency lock in techniques at temperatures from 20mK to 1K. The sample was mounted on a tilting stage which enabled us to apply high parallel magnetic fields, necessary for complete spin-polarization.

Results and Discussion

We first measured m* in a partially-polarized system, for which data is shown in Fig. 1(a). From the analysis of this data we find that m* is enhanced above the band value ($m^*=1.5m_b$) . Then, we repeated these measurements in a high parallel magnetic field which resulted in complete spin polarization of the system. Raw data are shown in Fig. 1(b) . To our surprise, we find that the value of m* is greatly suppressed, to values even lower than m_b ($m^*=0.75\ m_b$). In conjugation with the data taken from other samples in our lab, we find a consistent behavior: the complete spin polarization of the 2D system results in a m* suppression.

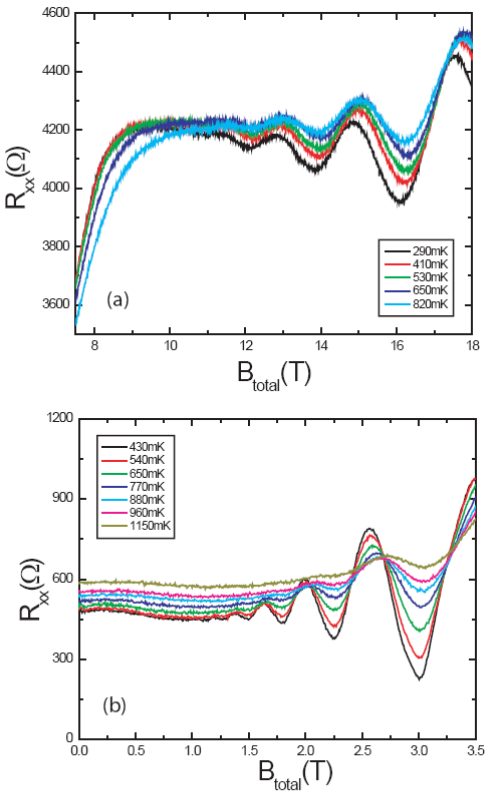

Figure 1

Conclusion

In summary, we have observed that the effective mass of electrons confined to a quantum well in AlAs is greatly influenced by the presence or absence of two spin species in the system. When the system is partially polarized, m* is larger than the band value irrespective of the degree of partial spin polarization. Once one spin species is completely depopulated, m* falls below band value.

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