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Power Dependence of the Amplitude of the Microwave Radiation Induced Magneto-Resistance Oscillations and Linear Polarisation

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Abstract

We have studied the power dependence of the amplitude of the microwave radiation induced magneto resistance oscillations and the linear polarization sensitivity of these oscillations. For the power dependence, some experimental results have indicated that the amplitude of the microwave radiation induced oscillations increase nonlinearly with the microwave power as the radiation driven electron orbit model has theoretically confirmed a nonlinear power relation. The microwave polarization dependence is concerned; the microwave radiation induced oscillations are in dependent of the polarization orientation for both linearly and circularly polarized microwaves. Microwave radiation induced oscillations are independent of the polarization orientation for both linearly and circularly polarized microwaves. Microwave radiation induces oscillation amplitudes do depend on the polarization angle of linearly polarized microwaves and that they follow a cosine square function of the polarization angle. We found that microwave photo excited electrons are scattered by impurities and this gives rise to an additional current density due to radiation. The inelastic model for magneto oscillations in the photo conductivity of the two dimensional which is governed by the microwave induced change in the distribution function, suggests a linear dependence in the amplitude with the microwave power that is independent of the linear microwave polarization.

Keywords: Power dependence, amplitude, microwave, magnetoresistance, polarization, oscillation, photoexited.

1. Introduction

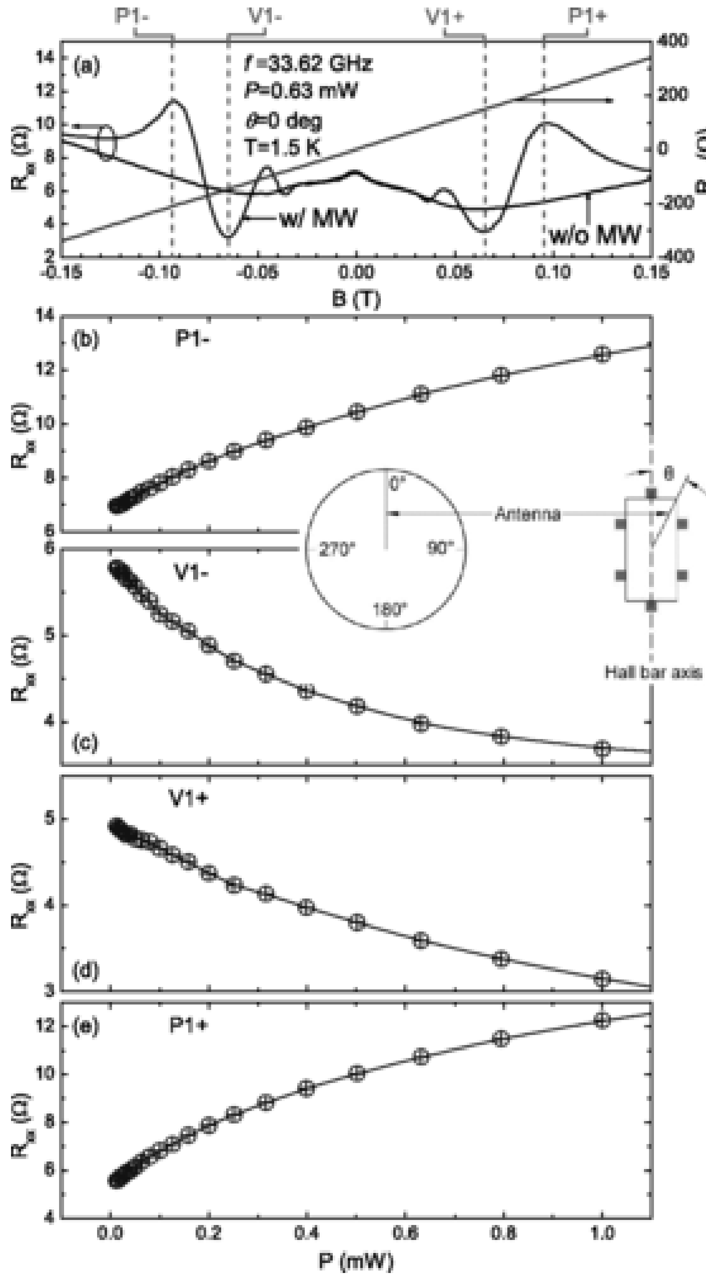
Mani et al. [1] and Zudov et al. [2] studied that microwave radiation induced zero resistance states arise from large amplitude $\frac{1}{B}$ periodic microwave radiation induced magneto resistance oscillations. Simovic et al. [3] and Bogan et al. [4] observations reported steady state nonequilibrium transport in low dimensional electronic systems. Wiedmann et al. [5] and Ye [6] also reported to stimulate much theory for associated steady state nonequilibrium transport. Pfeiffer et al. [7] studied the issue of the phase of the microwave radiation induced oscillations have been apparently been understood in favour of the $\frac{1}{4}$- cycle shifted oscillations, where the oscillatory minima occurred about $B = \left[4/\left(4j+1\right)\right]B_f$. Zudov [8] suggested a variable phase such that the phase becomes progressively smaller as microwave radiation induced oscillations evolved into zero resistance states with increasing magnetic field $B, B_f = \frac{2\pi m^* f}{e}$, f is microwave frequency, $\omega = 2\pi f, m^*$ is effective mass of electrons in Gallium Arsenide, e is electron charge, ω_c is the cyclotron angular frequency and j=1,2,3…. . Kovalev et al. [9] and Durst et al. [10] presented that the power dependence; some experiments results indicated that the amplitude of the microwave radiation induced oscillations increases nonlinearly with the microwave power. Dmitriev et al. [11] the elastic model suggested that the amplitude of the radiation induced magnetoresistance oscillations increase linearly with the microwave power. Inarrea et al. [12] theoretically confirmed a nonlinear power relation as the radiation driven electron orbit model. Smet et al. [13] experiments suggested that microwave radiation induced oscillations are independent of the polarization orientation for both linearly and circularly polarized microwaves. The obtained results were compared with previously obtained results.

2. Method

In this method Hall bars with gold –germanium alloyed contacts were fabricated on high mobility gallium arsenide hetro junctions by optical lithography. The specimens were mounted at the end of a long cylindrical waveguide, with the device normal oriented along the waveguide axis. The waveguide sample holder was then inserted into a variable temperature insert, inside the bore of a superconducting solenoid. A base temperature of about 1.5K was realized by pumping on the liquid helium within the variable temperature insert. The specimens were illuminated by a red LED at low temperature to realize the high mobility condition. A low frequency four terminal lock-in technique was adopted to measure the magneto resistance. A microwave synthesizer provided the microwave excitation and the microwave power at the source was changed at 1 dbm increments for the power dependence measurements. The linear polarization angle was changed by rotating the microwave launcher outside the cryostate and results were obtained.

3. Results and Discussion

Graph (1)(a) shows that a magnetic field sweep was performed with 33.62 Ghz microwave illumination to obtain the photo excited diagonal magneto resistance R_{xx}, following a field sweep to obtain the dark R_{xx} curve. The photo excited blue R_{xx} curve shows pronounced radiation induced magneto resistance oscillations on both side of the magnetic field axis. The peaks labled PI- and PI+ and the valleys laved VI- and VI+ deviate the most from the dark curve. We examined the power dependence and polarization dependence at the associated four fixed values of the magnetic field. Graph (1) (b) to (1) (e) exhibit the external oscillatory diagonal magneto resistance R_{xx} as a function of the source microwave power. Graph (1) (b) and (1) (e), exhibit the power dependence at the peak of the oscillatory resistance, R_{xx} increase as the power increases. Graph (1) (c) and (1) (d) show the power dependence at the valleys of the oscillatory resistance, R_{xx} becomes smaller as the power increase. The obtained results were compared with previously obtained theoretical and experimental results and were found in good agreement.



Graph 1: (a) Diagonal resistance R_{xx} (left ordinate) and Hall resistance (right ordinate) vs the magnetic field B and with microwave photo excitaion.

4. Conclusion

The obtained results showed that a nonlinear relation between the oscillatory peak magneto resistance and the microwave power. The result also showed a cosine square relation between the oscillatory peak, magneto resistance and the microwave polarization angle. A possible role for the device parallel component of electric field in influencing photo excited electron transport. Both the displacement model and the radiation driven electron orbital model confirmed the dependence of the microwave radiation induced oscillations on the polarization angle of linear polarized microwaves. The inelastic model also strongly supported that microwave radiation induced oscillations are insensitive to the polarization for both linearly and circularly polarized microwaves. We also found that the zero polarization angles mostly yielded to maximum effective power.

References

1. Mani R.G., Smet J. H., Von Kliting K., Narayanmurti V., Johnson W. B. and Umansky V., (2000), Nature (London), 420, 646.
2. Zudov M. A., Du. R.R., Pfeiffer L. N. and West K. W., (2003), Phys. Rev. Lett. 90, 046807.
3. Simovic B., Ellenberger C., Ensslien K., Tranitz. H.P. and Wegscheider W., (2005), Phys. Rev. B., 71, 233303.
4. Bogan A., Hatke A.T., Studenikin S.A., Sachrajada A., Zudov M.A., Pfeiffer L. N. and West K. W.,(2012), Phys Rev. B., 86, 235305.
5. Wiedmann S., Gusev G. M., Raichev O.E., Lama T.E., Bakarov A. K. and Portal J.C., (2008), Phys. Rev. B. 78, 121301.
6. Ye. T., Mani R.G. and Wegscheider W.,(2013), Appl. Phys. Lett., 102, 242113.
7. Pfeiffer. L., Smet J. H., Gorshunov. B., Jiang C., West K., Umansky V., Dressel M., Meisel R., Kuchar F. and Von Klitzing K., (2005), Phys. Rev. Lett., 95, 116804.
8. Zudov M.A., (2004), Phys. Rev. B, 69, 041304.
9. Kovalev A.E., Zvyagin S.A., Bowers C.R., Reno J.L. and Simmons A., (2004), Solid State Commun. 130, 379.
10. Durst A.C., Sachdeo S., Read N., and Girvin S. M. (2003), Phys. Rev. Lett. 91, 086803.
11. Dmitriev I.A., Vailov M.G., Aleiner I.L., Mirlin A.D. and Polyakov D.G., (2005), Phys. Rev. B., 71, 115316.
12. Inarrea. J, Nani R.G. and Wegscheider W., (2010), Phys. Rev. B., 82, 205321.
13. Smet J.H., Mani R.G., Von Klitzing K., Narayanamurti V., Jonson W.B., and Umansky V, (2004), Phys. Rev. Lett. 92, 146801.