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Power Dependence of the Amplitude of the Microwave Radiation Magnetoresistance and Polarization Sensitivity

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Abstract

We have studied the power dependence of the amplitude of the microwave radiation magnetoresistane oscillations and the linear polarization sensistivity of the oscillations. We have found that the amplitude of the microwave radiation induced oscillations increases nonlinearly with the microwave power. The inelastic model suggested that the apmplitude of the radiation induced magnetoresistance oscillations should increase linearly with the microwave power. It has been found that radiation induced oscillatory magnetoresistance in high quality gallium arsenide two dimensional electron systems indicated a nonlinear variation in the amplitude of the radiation induced magnetoresistance oscillations with the microwave power at the oscillatory extrema alongwith a cosine squared dependence on the polarization angle. A displacement model indicated the dependence of the oscillatory magnetroresistance on circular and linear polarization and the inelastic model has strongly supported that microwave radiation induced oscillations are insensitive to the polarization for both linearly and circularly polarized microwaves. In our work the transverse electric mode is excited by the microwave antenna and the specimen is subject to the TE_{11} mode of the circular waveguide. Microwave radiation stabilization of the edge ballastic trajectories, simulations show weakly depends on the microwave polarization axis and nonlinearly depends on the microwave power.

INTRODUCTION

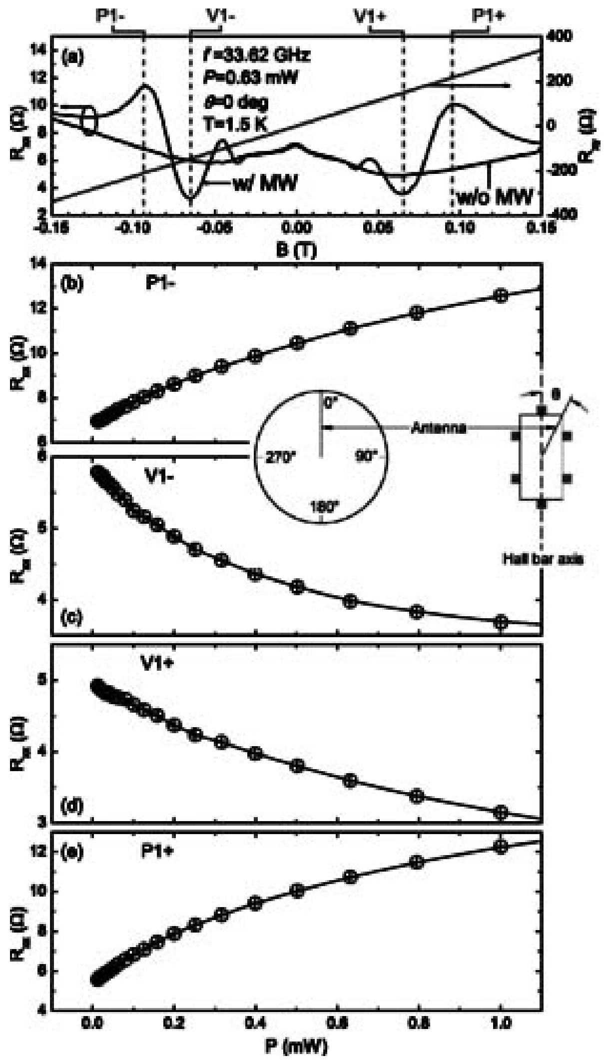
Mani etal [1] studied micro wave radiation induced zero resistance state arise from large amplitude 1/B periodic microwave radiation induced magnetoresistance oscillations. Bogan etal [2] showed the issue of the phase of the microwave radiation induced oscillations in favour of the ¼ cycle shifted oscillaations. Inarrea etal [3] reported experimental results for power dependence on the amplitude of the microwave radiation induced oscillations. Dmitriev etal [4] suggested that the amplitude of the radiation induced magnetoresistance oscillations should increase linearly with the micro wave power. Smet etal [5] suggested that micorwave radiation induced oscillations are independent of the polarization orientation for both linearly and circularly polarized microwaves. Lie etal [6] theoretically showed the displacement model and the radiation driven electron orbital model by Inrrea [7]confirmed the dependence of microwave radiation induced oscillations on the polarization angle of linear polarized microwaves. Durst etal [8] and Ryzhii [9] suggested that microwave photo excited electrons are scattered by impurities and this gives rise to an additional current density due to radiation. Chepeliankski etal [10] model suggested a microwave radiation stabilization of the edge. Zhirov etal [11] showed that a radiation driven electron orbital model described a periodic back and forth radiation driven motion of the electron orbits and the conductivity modulation resulting from the average coordinate change. This model shows both a nonlinear power dependence and a linear polarization angle dependence.

METHOD

Gold-germanium alloyed contacts were fabricated on high mobility gallium arsenide hetrojunction by optical lithography. The specimen were mounted at the end of long cylindrical wave guide. The waveguide sample holder was inserted into a variable temperature insert, inside the bore of a super conducting solenoid. The specimen were illuminated by a red light emitting diode at low temperature to realize the high mobility condition. A low frequency four terminal lock-in technique was adopted to measure the magnetoresistance. A microwave synthesizer provided the microwave excitation and the microwave power at the source. Linear polarization angle which is the angle between the long axis of the Hall bar and the microwave antenna in the microwave launcher outside the cryostat. A magnetic field sweep was performed with microwave illumination to obtain the photo excited diagonal magneto resistance.

RESULTS AND DISCUSSION

Graph (1) (a) shows the field sweep to obtain the dark R_{XX} curves. The photoexcited R_{XX} curve sows pronounced radiation induced magnetoresistane oscillations on both sides of the magnetic field axis. Graph (1) exhibit the external oscillatory diagonal magnetoresistnace R_{XX} as a function of the source microwave power. Graph (1) (b) and (1) (e) exhibit the power dependence at the peaks of the oscillatory resistance, R_{XX} increases 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 increases. The measurements of R_{XX} versus *p* at the magnetic fields corresponding to PI - , VI -, VI + of linear polarization angles over the range $0^0 \le \theta \le 360^0$ at 10^0 increments. Graph (1) shows that the external magneto resistance R_{XX} is a nonlinear function of the microwave power *p*. The peak magnetoresistance is a cosine square function of linear microwave polarization angle θ, which is equal to $R_{XX}(\theta) = A \pm c\cos^2(\theta - \theta o)$. We observed that the displacement model suggested that microwave photoexcited electrons were scattered by impurities and gave rise to an additional current density due to radiation and influence of the microwave radiation polarization. For electron transitions between nonadjacent Landau levels theory suggested a linear dependence of photoconductivity and microwave power *p* in a wider range microwave powers at the extrema of microwave radiation induced oscillations. In the case of transitions between neighboring Landau levels, theory indicated that photoconductivity versus microwave power dependence is nonlinear at the extrema of microwave radiation induced magnetoresistance oscillations with photo conductivity $|\sigma_{ph}| \alpha\, p^{-\frac{1}{2}}$ at high power. The obtained results were in good agreement with previously obtained results.



Graph 1: Diagonal resistance R_{XX} (left ordinate) and Hall resistance (right ordinate) vs the magnetic field B and with microwave photoexcitation.

CONCLUSION

We have found that the transverse electric mode is excited by the microwave antenna and the specimen is subjected to the TE_{11} mode of the circular waveguide. The electric field along the device axis or the effective field E_e is $E\cos\theta$, where E is applied AC electric field. Then $P_e = P\cos^2\Theta$ gives the relation between the effective and applied microwave power and the polarization angle. The results show that $\frac{P}{P_s}$ normalizes microwave power with different polarization angles to the same effective power scale. The displacement model suggested 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 suggests a linear dependence in the amplitude with the microwave power that is independent of the linear microwave polarization. The phase shifts of power scaling factor deviates at most by small angles from 0^0 which suggested the zero polarization angle mostly yields the maximum effective power. The obtained results were compared with previously obtained theoretical and experimental results and were found in good agreement.

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