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MAGNETO TRANSPORT AND MAGNETO OPTICAL CHARACTERISTICS OF INVERS--ETC(U)
JAN 82 N P ONG, A MADHUKAR AFOSR-78-3530

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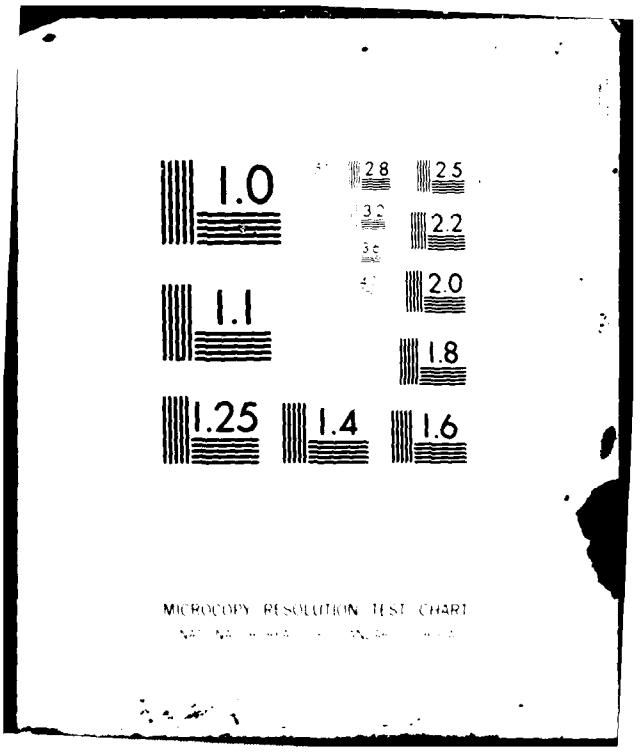
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SCIENTIFIC REPORT (Interim)

Grant #: AFOSR 78-3530

Title: Magneto-Transport and Magneto-Optical Characteristics of Inversion and Accumulation Layers

Period: Feb. 1, 1981 - Jan. 31, 1982

A. Theoretical Work:

The following theory projects were accomplished during the period Feb. 1, 1981 - Jan. 31, 1982.

(A.1) Theory of Magneto-conductivity (Shubnikov-de Hass Effect) in the presence of electron-impurity and electron-acoustic phonon interactions was developed. The memory function technique was employed and the contributions of the said interactions to the carrier scattering time and effective masses clearly identified. The work was published in Solid State Communications, 41, 29 (1982).

(A.2) The outstanding problem of the theory of Shubnikov-de Haas effect under the simultaneous presence of electron interaction with impurities, acoustic phonons and each other (i.e., e-e interaction) was examined and brought to a successful conclusion. The first correct structure of the expression for longitudinal magneto-conductivity was derived, showing the occurrence of two different effective masses and scattering times, in accordance with the behavior suggested by experiments. Individual contributions of the three interaction mechanisms to these effective masses and scattering times were explicitly identified and calculated. The dependence of the magneto-conductivity on carrier concentration, temperature and magnetic field is provided. This work was published in Surf. Sc. 113, 273 (1982).

(A.3) A Theory of "Cyclotron Resonance" in a 2-dimensional Wigner crystal was worked out. The work was motivated by the observed anomalous behavior of line position and width in "cyclotron resonance" experiments on GaAs/AlAs heterostructures and Si MOS inversion layers at low temperatures and carrier concentrations. Taking the view that if the Wigner solid phases has indeed been realized (as was suggested in the

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interpretation of these experiments) then the observed behavior should be viewed in terms of magneto-absorption by the phonon modes of the Wigner solid, we calculated the same for both single phonon and multiphonon absorption in the presence of coupling to the substrate phonon modes (which act as the heat bath). An explicit expression for the dependence of the magneto-absorption line width on the temperature, magnetic field and carrier concentration, in the Wigner solid regime, was provided. It provides the expected signature of the Wigner solid and being radically different from the behavior of the free electron gas cyclotron resonance, should be the expression against which relevant experimental observations can be checked. This work was published in Surf. Sc. 113 318 (1982).

(A.4) Sub-band Structure of InP Accummulation Layers: Work started in the previous reporting year was brought to completion. This work was published in Sol. St. Comm. (March, 1982).

(A.5) Work was begun on the behavior of shallow impurity levels in two dimensionally confined systems such as the GaAs/AlGaAs quantum well structures. Results within the hydrogenic model and the effective mass approximation were obtained to examine the changes away from the bulk behavior of shallow donors due to the confinement. The effective mass approximation did not appear justified for most situations. Consequently we chose not to publish these simple model results, even though two other groups chose to do so. We are presently examining ways of relaxing the effective mass approximation.

(A.6) Work was begun on a theory for ionized impurity and phonon scattering effects on the d.c. low field mobility of 2 dimensionally confined charge carriers in modulation doped systems. This "remote" scattering is being investigated within the memory function technique which does not involve the (inadequate) Boltzman equation and relaxation time approximations.

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MATTHEW J. KERPER
Chief, Technical Information Division

B. Experimental Work:

The experimental part of this project consisted of two parts. In the first, work was completed on the Far-infrared molecular laser system for the cyclotron resonance studies of the two dimensional electron gas in Si MOSFETS and GaAs/GaAlAs hetrostructures. The testing of the cryogenics (header, light pipes and sample mount) was completed and a report of the experimental set-up is in preparation. Currently, measurements on the cyclotron absorption in Si(100) inversion layer are in progress. Negotiations to obtain suitable devices based on InP from Hughes Research Lab were started. We have also started a program at USC Materials Science Department to fabricate GaAs/GaAlAs heterostructures.

In the second part extensive measurements of the dc magneto transport properties of Si(100) MOSFET were carried out in magnetic fields up to 10 Tesla. We have observed strong non-Ohmic behavior in the lowest Landau level and have made a systematic study of the non-Ohmicity versus E field, temperature and gate voltage. Follow-up measurements of these unusual transport properties are in progress.

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Publications:

1. "Theory of Transverse Static Magnetsconductivity in a Two Dimensional Electron-Phonon System", M. Grabowski and A. Madhukar, Solid State Comm., 41, 29 (1982).

2. "Quantum Theory of Magnetotransport in Two Dimensional Systems with Electron-Impurity, Electron-Phonon and Electron-Electron Interactions", M. Grabowski and A. Madhukar, Surf. Sc. 113, 273 (1982).

3. "Theory of Cyclotron Resonance in a Two Dimensional Wigner Crystal", B. Horovitz, M. Grabowski and A. Madhukar, Surf. Sc. 113, 318 (1982).

4. "Energy Levels of n-channel Accummulation Layer on InP Surface", S. Das Sarma, Solid State Comm. (1982).

5. "Thermal Relaxation of Two-dimensional Electron Gas in a Magnetic Field", N.P. Ong and G. Kote, Bull. Am. Phys. Soc., 27, 251 (1982).

6. "Electric Field Dependence of the Resistivity of the Two Dimensional Electron Gas in a Strong Magnetic Field", G. Kote and N.P. Ong (manuscript in preparation).

7. "Temperature Dependence of the Magnetoconductance of the Two-Dimensional Electron Gas in the Localized Regime", G. Kote and N.P. Ong (manuscript in preparation).

8. "Use of Carbon Bolometers for Far-infrared Detection in a Strong Magnetic Field", F. Boero and N.P. Ong, (manuscript in preparation).

9. "The Construction of a Far-infrared Laser for Cyclotron Resonance Experiments", F. Boero and N.P. Ong (manuscript in preparation).

Personnel:

1. A. Madhukar (P.I.)

2. N.P. Ong (P.I.)

3. M. Grabowski (Post Doctoral Res. Associate; Theory; Jan., 1981 - Sept., 1981).

4. S. Das Sarma (Post Doctoral Res. Assoc.; Theory; Jan. 1979 - Sept. 1980).

5. G. Chrysostomou (Graduate Student; Theory; June, 1981 - Dec. 1981).

5. G. Kote (Post Doctoral Res. Assoc., Expt.; Jan 1979 - present)

6. F. Boero (Graduate Student; Expt.; Jan 1979 - present)

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Theoretical computations were completed and published on the following topics: Shubnikov-de Haas effect with electron - impurity, electron-phonon interactions; cyclotron resonance in A 2-D Wigner crystal; sub-band structure for InP accumulation layers. A for -infrared molecular laser was constructed and measurements made on cyclotron obsorption in Si (100) inversion layers. D.C. Magneto-Transport properties of Si (100) MOSFET's were carried out.

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