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奈米人工結構及元件電子傳輸之物理特性研究
Physics of Electrical Transport in Artificial Nanometer Structures and Devices

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中文摘要

低溫及低維度系統之電子傳輸的研究自從量子接觸點(Quantum Point Contacts)在 1988 年首度被實現後一直蓬勃發展至今,雖然在短短時年的時間裡已經有了相當多的研究，尤其量子線(Quantum Wires)及量子點(Quantum Dots)展現異於古典物理現象的探討。然而，對於稀少電子系統中所牽涉之電子－電子及電子－生子間之交互作用；低維系統中電子與區域磁偶矩（量子化磁通）的交互作用；及高磁場下形成量子化霍爾效應的 edge state 之電子傳輸依然有待進一步的探討。本計畫的目標是延續本實驗室近年來經國科會及本校支助完成之軟硬體設備；並延續本實驗室近兩年之毫微米結構製作及低溫量測經驗，投入探討前述問題。在本計畫中，我們將在 0.3K 低溫環境下探討半導體低維電子系統(Low Dimensional Electron Gas Systems)的物理現象，其中包括：（１）低維稀少電子系統中單電子間及電子－聲子間之邀互作用和單電子充放電的特性研究；（２）低維系統中電子與磁偶矩（甚至區域性量子磁通）的作用，如 Condo 效應；（３）低維電子系統在高磁磁場下形成 edge state 的電子傳輸現象。

元件將建構於砷化鎵/鋁砷化鎵(AlGaAs/GaAs Heterostructure)夾層中之二維電子雲系統中。技術上，以本實驗室具備之解析度達 30 毫微米電子束微影術(Electron Beam Lithography)以製作毫微米金屬閘結構(Split Gates)，完成之元件將以場效(Field Effect)的原理來調制電子通道，使該系統由二維進而到一維，更甚到零維(Quantum Dots)的系統。同時低溫量測將於 0.3K 系統(Heliox VL 且配備磁場 4T)中進行。

關鍵字：電子接觸點; 量子線; 量子點; 稀少電子系統; 量子化磁通; 量子化霍爾效應; 金屬閘結構

Abstract

It has been of great interest in the studies of low dimensional electron transport in low temperature ever since quantum point contact was first realized in GaAs/ AlGaAs heterostructure at 1988. Structures of quantum wires and quantum dots, which exhibit quantum behavior, are of great interest to the fundamental research as weII as practical applications. Recently, subjects such as few electron systems for the studies of electron-electron/electron-phonon interaction and single electron charging effect; low dimensional electron and local magnetic moments (even quantum flux) interaction; and edge state under high magnetic field are the hot topics. Herein, we propose a two-year project working on the subjects as following (l) few-electron systems for the studies of electron-electron/electron-phonon interaction and single electron charging effect; (2) low dimensional electron and local magnetic moment interaction; and (3) edge state transport under high magnetic field.

Split-gate technique in conjunction with wet etching technique will be adopted. The designed structures will be fabricated in GaAs/ AIGaAs heterojunction by using electron beam lithography, in which the lithographic system that has been set up at National Changhua University of Education shows a best resolution of 30nm. The characterization will be carried out in a Heliox VL low temperature system. By applying negative bias on the split metal gates for field effect modulation the start-up two-dimensional electron gas system becomes one-dimensional (or even zero-dimensional) systems, with which the low dimensional system is realized for the studies. We are aiming to explore the aforementioned fundamental Physics as well as potential applications.

Key words：Quantum Point Contact; Nanostructure; Quantum Wires; Quantum Dots; Low Dimensional Physics