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低維度系統之電子自旋傳輸特性研究
Electron Spin Transport in Low Dimensional Systems

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中文摘要

我們提議一個三年期之計畫，本計畫目標是研究低維度系統下之電子自旋傳輸特性，尤其異於古典物理的現象探討。在本計畫進程中，我們將集中探討場效調製下半導體低維繫統及人工合成之奈米碳管系統，而場效的效應將分別採用電場及區域磁場的調變調製作用，進而在這些低維度系統下瞭解磁性相干之電子傳輸的基礎物理現象。其中包括：(1)自旋極化電子注入之研製；(2)自旋極化電子傳輸中之自旋遲緩時間(spin relaxation time)之探究，尤其在低維度及稀少電子系統中電子與磁偶矩(甚至區域性量子磁通)的作用；和(3)牽涉自旋傳輸特性之物理現象之探討，進而探究瞭解相關之潛能應用。元件結構將實現於兩大系統：(1)建構於砷化鎵/鋁砷化鎵高品質異質接面之二維電子雲系統中，技術上以本實驗室具備之解析度達 20 奈米電子束微影術，製作奈米金屬閘結構，同時結合掏域化之奈米級磁矩製作，完成之元件將以磁及電之場效的原理來調制電子通道，使該系統由二維進而到一維，更甚至到零維之稀少電子的系統；(2)人工合成奈米碳管之一維電子通道，並結合以電子束微影技術製作覆蓋之一般及磁性金屬接觸點，藉以施加電及磁的調製。有關低雜訊之量測，則將於配備 4T 磁場之 0.3K 系統中進行。

關鍵字：電子自旋傳輸; 半導體低維系統; 奈米碳管; 自旋遲緩時間; 電子束微影術

Abstract

A three-year project is proposed and the objective is to work on the subjects of electrical spin transport in low dimensional systems. The systems studied will include field-modulated GaAs/AlGaAs heterojunction two dimensional electron gas systems and Carbon Nano-tubes (CNTs) in conjunction with nanoscale local magnetic moments, in which the field modulation may come from electrical field as well as local magnetic moment. In such systems, some fundamental spin-related transport phenomena will be investigated, such as (1) spin injection into low dimensional system; (2) the spin relaxation time in the low dimensional systems, especially the interaction between the spin polarized electron and the local magnetic moment in the few electron systems; and (3) the spin-related phenomena for potential applications. Devices will be based on two different systems: (1) is the high quality GaAs/AlGaAs heterostructures in conjunction with split-gate technique. The split metal gates will be fabricated by using electron beam lithography, in which the highest spatial resolution has been shown to be 20 nm. Under the field modulation, the two dimensional electron gas started at the interface of GaAs/AlGaAs shall be further narrowed into one dimensional regime, even zero dimensional regime; and (2) is the artificially grown of Carbon Nanotubes. By combining the dispersion of the nanotubes, casting, locating, lithographic process, metal evaporation, and then lift-off process, normal metal and magnetic electrical contacts shall be made by mainly using electron beam lithography. The characterization will be carried out in a Heliox VL low temperature system.

Key words：Spin Transport; Heterojunction; Few Electron System;
Carbon Nanotubes; Electron Beam Lithography