多組偏壓侷域之量子尖端接觸元件的電性量測

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中文摘要

我們利用了微影技術在 GaAs/AlGaAs 異質接面結構的樣品上製作不同幾何結構的金屬閘極，在低溫的環境中，得到一個介觀彈道傳輸的系統，藉由不同的金屬閘極結構，來研究介觀系統中的電性傳輸。

在單一對分離閘極結構中，我們在閘極上外加負偏壓，造成有效位障對二維電子氣形成窄通道結構，控制閘極偏壓的大小，可以改變窄通道的寬度，進而改變窄通道中被費米電子所佔據的次能帶數（n），觀察到類一維的量子化電導現象。串聯量子尖端接觸結構上，我們發現，隨著距離的改變，電子的傳輸特性也會改變，當兩對 QPC 距離很近時（$\leq 1.1\,\mu m$），電子傳輸屬於絕熱傳輸特性，且在量子化電導上會額外出現共振結構；隨著兩者間距離漸拉大，電子傳輸特性漸偏向於歐姆傳輸，串聯的 QPC 可視為兩對獨立的 QPC 而不互相影響。除此之外，我們亦發現，當兩 QPC 距離近，且其中一對的 n 值限制在<1 的地方，此時量子化電導便不存在。

量子抽運電流方面，我們使用雙層分離閘極結構來產生一個抽運系統：兩支指狀閘極跨在一對分離閘極上端；加一固定負偏壓固定分離閘極所形成的窄通道寬度，並在兩支指狀閘極上加一同頻且有一相位差的高頻 AC 訊號。藉由改變相位差，發現樣品可在無外加偏壓下自主地產生一抽運電流；量測上我們將此抽運電流轉換成電壓 V_{DC}。在抽運電流量測上，我們發現了 V_{DC} 震盪跟相位差成正弦曲線的關係，隨著頻率越高，V_{DC} 震盪的幅度越大，若在無限制位能的情況下，即未形成類一維窄通道下，只是一些雜訊

背景值（$\leq 10^{-7}$V），與相位差無關，證實我們在一維的窄通道系統中，確實可以藉由時變高頻位能場產生抽運電流。

Electrical transport in multiple gated quantum point contacts

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Abstract

A mesoscopic ballistic system on the GaAs/AlGaAs heterostructures at low temperature can be obtained by the lithographic technology In this work, we study the electron transport properties of various geometries systems in the reduced dimensions.

When a negative bias is applied to a pair of split gate, the underlying two dimensional electron gas is electrostatically squeezed into a quasi-1D channel. By changing the negative bias, the channel width and corresponding occupied subband number（n）below E_F are varied. The phenomenon of conductance quantization is observed. In the structure of the QPC’s in series, we find the electron transport changes with distance between two QPC’s. When two QPC’s are close to each other（$\leq 1.1\mu m$）, transport demonstrates the adiabatic behavior, and there is resonant structure superimposed on conductance plateaus. With increasing the distance, transport behaves Ohmically and hence, QPC’s in series act as two individual QPC’s. Besides, we find that when two QPC’s are close to each other and n is less than 1 the quantized conductance vanishes.

In the aspect of quantum pumping, we obtain a pumping system of the bi-layer gate structure：Two finger gates are arranged atop a pair of split gate. A negative bias is applied to split gates to control the channel width. Two high frequency AC signals with the same frequency and amplitude but different phases are applied to two finger gates. By changing the phase difference, the system can generate a dc current spontaneously without external bias.

Experimentally, we transform the pumping current into the voltage $V_{DC.}$ The V_{DC} demonstrate sinusoidal dependence on phase difference φ and becomes larger with increasing pumping frequency. When the channel is not confined to form a quasi-1D system, the V_{DC} is close to zero, the background noise（$\leq 10^{-7}$V）,and is independent of phase difference φ. Thus we confirm that a DC current can be generated spontaneously in a 1D channel with time-varied high frequency electrostatic potential.