封閉式量子點系統之庫侖阻絕振盪

學生：林玉敏　　指導老師：許世英 副教授

國立交通大學電子物理研究所

摘要

我們在 GaAs/AlGaAs 異質接面結構中存在的二維電子氣系統(two-dimensional electron gas，2DEG)，利用光微影技術與電子束微影技術，製作出不同幾何形狀的量子點閘極結構，元件大小在微米尺度。並探討在電子在介觀系統內的彈道傳輸特性。

外加負偏壓於量子尖端接觸(quantum point contact)結構，在其間可產生一維位障通道，觀察電子在彈道傳輸範疇中的量子電導化現象。在量子點的閘極結構上，外加負偏壓於閘極結構，使二維電子氣被局域形成封閉式量子點，量子點內的能階並隨著維度的減少而有明顯的分開。我們藉由抽運閘極上的電壓來調變量子點內的電位能階，使其介於汲極與源極的化學能之間，電子能以穿遂的方式進出量子點。並利用定電壓源電路來測量，在封閉式量子點系統觀察到在電導-電壓關係的庫侖阻絕震盪現象。這些電導峰值相對的電流值約 0.7pA，與一個穩定封閉式量子點的電導雜訊背景值(相對的電流值約 0.1pA)相比，我們可以確認量測到的訊號為庫侖阻絕震盪。

由我們的實驗數據中，測量到的庫侖阻絕震盪的峰值間距($\triangle V_g$)約 meV 左右。我們並估算量子點在溫度為 0.3K 的 level spacing ($\Delta \approx 2.6\mu eV$)，和 charging energy ($U \approx 343\mu eV$)。因此在我們測量的溫度局域為 $kT < \Delta < U$ ，量子點表現為

古典庫侖阻絕效應，庫侖阻絕震盪的電導峰值約略相同。

Coulomb Blockade Oscillation in Closed Quantum Dot Systems

Student：Yu-Min Lin **Advisor：Prof. S.Y. Hsu**

Institute of Electrophysics

National Chiao-Tung University

Abstract

We fabricated various sub-micron quantum dot structures by lithographic technology on the GaAs/AlGaAs hetero-structure with a two-dimensional electron gas at the interface. In this work, we study the electron transport properties in mesoscopic ballistic regime in quantum point contact and quantum dot systems.

Experimentally, a one-dimensional narrow channel can be formed by applying negative bias to a pair of split gate. The phenomenon of conductance quantization can be observed. A closed quantum dot system can be formed by applying negative bias to several metal gates. The energy level is clearly discrete due to the reduction of dimension. The chemical potential of the dot can be shifted by tuning the voltage of pumping gates. Thus, the electrons can tunnel on and off the dot via the single state that lies between the chemical potential of source and drain. By the common voltage circuit, Coulomb Blockade oscillation is measured in closed quantum dot systems. The currents corresponding to the peak of conductance are around 0.7pA, larger than the background noise, 0.1pA. We can confirm that the signals are from Coulomb Blockade oscillation.

Our results show that, the measured peak spacing $\triangle V_g$ is around meV. We can estimate that $\Delta \approx 2.6\mu eV$ and $U \approx 343\mu eV$ at T=0.3K. Therefore, in our measurement range that $kT < \Delta < U$, dot exhibits classical Coulomb Blockade and the heights of CB peaks are roughly constant.