巨觀振盪系統之動態研究

A. 受迫約瑟芬森交流效應 RSJ 模型與量子霍爾效應

B. 鈦酸鍶雷射濺鍍磊晶成長中中斷反射高能電子繞射振盪後之強度回復

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中　文　摘　要

本論文探討巨觀振盪系統的動態行為，一是從古典非線性共振或稱鎖相行為的觀點比較巨觀量子系統的受迫超導約瑟芬遜交流效應與量子霍爾效應的相似性．另一則是討論反射式高能電子繞射在雷射磊晶薄膜成長的退火分析中，中斷振盪的繞射電子束強度和表面台階邊緣的擴散動態行為的關聯性．

當二維超導約瑟芬遜結所受的外加直流電流大於臨界電流時，在結兩端將產生一電壓降並伴隨一交流電流，而當外加一微波輻射時，則電壓隨直流電流的改變而出現台階。這階梯狀的 I-V 特性曲線可以用 RCSJ(電阻電容分流等效電路)模型來描述，其方程式類似一週期受迫非線性振盪。當系統在鎖模狀態時，自然頻率與外力頻率以整數或分數比例鎖定，而約瑟芬遜交流效應中的電壓階梯即可由此機制解釋。依照 P.W. Anderson 的模型，從磁漩渦的觀點來看交流約瑟芬遜效應，約瑟芬遜振盪是由磁漩渦在靜止的電子背景中橫向移動造成。吾人若將此圖像放寬為磁漩渦與電子的-二維相對運動，則便可以用一個 ”類約瑟芬遜振盪” 來描述定磁場下電子運動的情況，也就是霍爾效應。在考慮相干的霍爾電流之後，電子波在固定觀察點的振盪對系統而言，就形成了一個外加的振盪。因此量子霍爾效應便可以看成一個週期受迫振盪問題，而霍爾電阻台階即由精細結構常數 e^2/h 的倒數和 ”磁/電” 振盪的頻率比所決定。

反射式高能電子繞射(RHEED)強度與二維磊晶表面演化的關係一向受到重視，尤其是 RHEED 強度的週期性震盪對應於磊晶的規律層狀

重複成長更被視為重要的薄膜品質監控技術. 吾人在對鈦酸鍶雷射鍍膜定溫退火的即時紀錄實驗中, 發現 RHEED 強度與薄膜表面台階邊緣的密度，乃至於其動態擴散行為有密切的定量關係. 論文中並且直接從 RHEED 強度畫出擴散的 Arrhenius 圖而得到孤立線缺陷合理數值的擴散活化能。而在另一系列室溫濺鍍薄膜連續升溫回火的 RHEED 實驗中由 Kissinger 圖得到另一較高的活化能值，此兩個活化能的存在指出在 MBE 層狀鍍膜過程 RHEED 強度回復實驗中可能不同的兩個平坦化機制。直接分析 RHEED 強度不僅給出擴散的動力學特性，這項發現也可作為對 RHEED 繞射強度振盪發展力學模型提供啟發支持.

Studies on Dynamics of Macroscopic Oscillatory Systems

A. RSJ Modeling Driven Josephson ac Effect and Quantized Hall Effects.

B. Recovery of Interrupted RHEED Oscillation in $SrTiO_3$ Laser Ablation Epitaxy Growth

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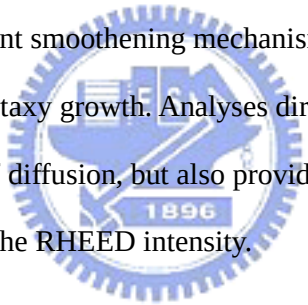
ABSTRACT

Dynamical behaviors of two oscillatory many body systems have been investigated. From a classical nonlinear resonance or phase-locking point of view, we firstly discuss the similarity between two macroscopic quantized systems, namely the driven superconductive Josephson ac effects and the quantized Hall effects. The other system under study involves the correlation between the reflection high energy electron diffraction intensity of interrupted STO laser deposition and the kinetic characteristics of the surface step edges.

The I-V characteristics of the Shapiro steps of a 2 dimensional superconductive Josephson junction can be described by the Resistively and Capacitively Shunted Junction (RCSJ) model. The governing equation is equivalent to a periodically driven nonlinear oscillator. When the system falls into the phase-locked state, the natural frequency and the external frequency lock in an integer or a rational ratio. Under a postulate of dynamic macroscopic quantization, the quantized Hall effects have been modeled with a periodically forced oscillation as the rf driven Josephson ac effects. The Hall voltage steps can be obtained as a ratio between the reciprocal of fine structure

constant e^2/h and the frequency of the electro-magnetic oscillation.

The relation between the RHEED intensity oscillation and the 2-dimensional layer by layer growth was another macroscopic dynamical system under investigation. During the in-situ recording on the constant-temperature annealing of interrupted laser ablation Strontium Titanate, we found quantitative correlation between the RHEED intensity and the density of the line dislocations on the surface. By drawing the diffusion Arrhenius plot directly from the RHEED intensity we obtained a reasonable value for the activation energy of the isolated step edge migration. In a series of RHEED experiments with different heating rates for room temperature deposited films, a higher activation energy is obtained from the Kissinger plot. These two activation energies together suggest two different smoothening mechanisms during the recovery of the RHEED intensity in the Epitaxy growth. Analyses directly on the RHEED intensity not only gives us the kinetics of diffusion, but also provides inspiring supports for the dynamic model describing the RHEED intensity.



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