

國 立 交 通 大 學

顯示科技研究所

碩士論文

鐵電型液晶相位光柵元件之研究

The Study of Ferroelectric Liquid Crystal Binary

Phase Grating Devices



研 究 生：楊謹瑋

指 導 教 授：陳皇銘 博士

中 華 民 國 九 十 七 年 六 月

鐵電型液晶相位光柵元件之研究

The Study of Ferroelectric Liquid Crystal Binary

Phase Grating Devices

研究生：楊謹瑋

Student: Chin-Wei Yang

指導教授：陳皇銘

Advisor: Huang-Ming Philip Chen

國立交通大學

顯示科技研究所

碩士論文

A Thesis

Submitted to Display Institute

College of Electrical Engineering and Computer Science

National Chiao-Tung University

in Partial Fulfillment of the Requirements

for the Degree of

Master

in

Display Institute

June 2008

Hsinchu, Taiwan, Republic of China.

中華民國九十七年六月

鐵電型液晶相位光柵元件之研究

研究生：楊謹瑋

指導教授：陳皇銘 博士

國立交通大學顯示科技研究所

摘要

近年顯示科技領域發展，液晶光學研究及各式液晶材料合成進步，更加廣泛應用在於顯示科技上，而不僅僅是在顯示方面，更應用於光電元件，在此研究我們提出一種元件結構是經由兩片週期線條 ITO 玻璃對位重疊製成空 cell，因而形成 ITO 區塊與非 ITO 區塊週期交錯，並灌入液晶來製程可調控式液晶光柵，利用週期光柵電極產生之均勻電場調控液晶排列，因而形成所謂 Binary phase grating。

本研究使用鐵電型液晶材料(R3206-50)，此材料除了具有快速響應特性外，也具有較低的飽和電壓，約 5V。然而在實際用上，受限於排列不佳的問題。本實驗藉由調整配向膜的表面正負極性，來解決水平山形袖章結構之缺陷，形成單一方向排列之層結構。近幾年來利用鐵電型液晶光學特性來製作光柵的方法提出很多，比較其眾多方法及不同材料利用，此液晶光柵具有相當程度的優勢，兼具快速反應時間(1.3ms)、低驅動電壓(5V)、較低的 fringing field effect、較高的繞射效率(25.8%)以及低散射效果。

The Study of Ferroelectric Liquid Crystal Binary Phase Grating Devices

Student: Chin-Wei Yang Advisor: Dr. Huang-Ming Philip Chen

**Display Institute
National Chiao Tung University**

Abstract

A novel ferroelectric liquid crystal phase grating has been successfully prepared by periodically ITO (indium-tin-oxide) patterned stripes cell. Under external driving voltage, LC molecules were reoriented in ITO areas and cause phase difference between the areas without ITO. The binary phase gratings were formed within periodically alternating domains.

In this work, ferroelectric liquid crystal materials (R3206-50) were prepared. Low driving voltage FLC material, R3206-50 with V_{sat} at 5V (AZ Electronic Materials), and its were under evaluation for liquid crystal optical devices application. The horizontal chevron alignment defects were suppressed by asymmetric hybrid alignment cell, and the fringing field effect was reduced with low driving voltage (5V). The response time of R3206-50 was under 1.3 ms in a 1.6 μm cell. Thus, a desirable fast switching, low driving voltage, low fringing field effect, low scattering effect and easy process FLC grating was presented.

誌謝

碩士班求學兩年來，非常感謝我的指導教授陳皇銘老師，研究期間給予我實驗上該秉持的專業想法及態度，特別是鼓勵我勇於挑戰更有創新及獨特的研究且讓我發揮自己想法，過程中確實讓我成長許多，也讓自己擁有該有的專業能力及知識，讓我順利完成碩士求學期間的研究及論文。

回顧碩士這兩年來最常生活在一起打拼做研究莫過於實驗室的同學、學長姐、學弟妹們，很感謝怡帆、祥志以及蓮馨，在這兩年修課、拼戰實驗及生活上的幫忙，也感謝學長姐們-淇文、昆展、俊民、威慶、佑儒、耿睿、佳恬、世民、宜揚、耀慶、文孚以及玢綺在我一踏進實驗室給予我很多研究知識及實驗上的指導及幫助，再來感謝學弟妹們-宣穎、丞富、智弋、建佑及毓筠在實驗室幫忙學長分擔一些實驗雜事及幫忙。



最後，再此感謝我的家人及好友們在我研究低潮的鼓勵及精神上的支持，給我堅持下去的力量，讓我順利完成碩士的學業，很高興能將這份喜悅分享給所有幫助、關心我的人。

Table of contents

Chinese abstract	iii
English abstract	iv
Acknowledgement	v
Table of contents	vi
List of Figures	vii

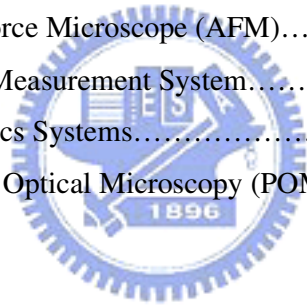
Chapter 1	Introduction	
1.1	Liquid Crystal Binary Phase Grating.....	1
1.2	Liquid Crystal Phases.....	2
1.3	Types of Liquid Crystal Gratings.....	6
1.3.1	Liquid Crystal Phase Gratings Review.....	6
1.3.2	Laser-induce Holographic Gratings.....	7
1.3.3	Patterned Photo-polymerization.....	9
1.3.4	Patterned-ITO Electrodes.....	10
1.4	Projection Displays by Binary Phase LC Grating.....	11

Chapter 2	Ferroelectric Liquid Crystal Phase Grating	
2.1	Introduction of FLC Phase Grating.....	12
2.2	Overview of SSFLC Devices.....	13
2.2.1	SSFLC Structure.....	13
2.2.2	Zigzag Defect in SSFLC.....	14
2.2.3	Horizontal Defect in SSFLC.....	15
2.2.4	Method to Erase Zigzag Defect.....	17
2.2.5	Eliminate Horizontal Defect.....	19
2.2.6	Summary.....	20
2.3	The Basic Theory of Polarizing Binary Diffraction Grating.....	21
2.4	Optical Properties of Liquid Crystals.....	25
2.5	Analysis of FLC Phase Grating.....	27
2.5.1	Grating Schematic.....	27

2.5.2	Diffraction Model.....	28
2.5.3	Polarization-independent FLC Phase Grating.....	29

Chapter 3 Materials 、 Fabrication Process and Instruments

3.1	Introduction of Grating Pattern Process.....	30
3.2	Grating Pattern Mask Design.....	31
3.3	Fabrication Process.....	32
3.3.1	Materials Preparation.....	32
3.3.2	Cell Fabrication Process.....	33
3.4	Observation of Thickness and Patterns of Thin-ITO Glasses.....	34
3.4.1	Observation of Thickness of Thin-ITO Glasses.....	34
3.4.2	Observation of Etched and Overlapped-ITO Patterns.....	35
3.5	Measurement Instruments.....	36
3.5.1	Atomic Force Microscope (AFM).....	36
3.5.2	Cell Gap Measurement System.....	38
3.5.3	Laser Optics Systems.....	41
3.5.4	Polarizing Optical Microscopy (POM).....	42



Chapter 4 Experimental Results and Discussion

4.1	Introduction of Experimental Objective.....	43
4.2	Diffraction Efficiencies of 100nm and 13nm ITO Glass.....	44
4.3	Surface Morphology.....	45
4.4	FLC Material (R3206-50) Distinctions.....	46
4.4.1	Alignment ability.....	46
4.4.2	Electro-Optical Properties.....	47
4.5	Experiment Part 1: The Period 20um and 2um Cell Gap.....	48
4.5.1	Grating Alignment Texture.....	48
4.5.2	Diffraction Efficiencies.....	49
4.6	Experiment Part 2: The Period 40um and 2um Cell Gap.....	50
4.6.1	Grating Alignment Texture.....	50
4.6.2	Diffraction Efficiencies.....	51

4.7	Experiment Part 3: The Period 38-40um and 2um Cell Gap.....	52
4.7.1	Grating Alignment Texture.....	52
4.7.2	Diffraction Efficiencies.....	53
Chapter 5	Conclusions	
5.1	Summary.....	54
5.2	Future Works.....	54
References	55

