

# Table of Contents

**Abstract (Chinese)**

**Abstract (English)**

**Acknowledgments**

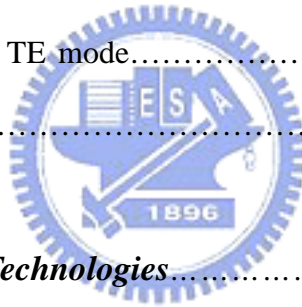
**Table of Contents**

**List of Tables**

**Figure Caption**

<b><i>Chapter 1 Introduction</i></b> .....	1
<b>1.1 Introduction of Micro-optical pickup</b> .....	1
<b>1.2 The frame of our micro-optical system</b> .....	6
<b>1.3 Introduction of micro polarization beam splitter (PBS)</b> .....	7
<b>1.4 Current researches of micro thin-film PBS</b> .....	8
<b>1.5 Motivation and objective of this thesis</b> .....	8
<b>1.6 Organization of this thesis</b> .....	8
<b><i>Chapter 2 Principle</i></b> .....	10
<b>2.1 Introduction</b> .....	10
<b>2.2 Principle</b> .....	10
2.2.1 Transmittance, Reflectance and absorptance.....	10
2.2.2 Brewster angle.....	13
2.2.3 $2 \times 2$ Matrix formulation for a thin film.....	13
<b>2.3 Summary</b> .....	17

<b>Chapter 3</b>	<b><i>Design and Simulation</i></b>	<b>18</b>
<b>3.1</b>	<b>Introduction</b>	<b>18</b>
<b>3.2</b>	<b>Design</b>	<b>18</b>
<b>3.3</b>	<b>Simulation</b>	<b>20</b>
3.3.1	PBS for red light	21
3.3.1.1	Incident angle	22
3.3.1.2	Transmittance of TM mode	23
3.3.1.3	Reflectance of TE mode	24
3.3.2	PBS for blue light	25
3.3.2.1	Incident angle	25
3.3.2.2	Transmittance of TM mode	26
3.3.2.3	Reflectance of TE mode	27
<b>3.4</b>	<b>Summary</b>	<b>28</b>
<b>Chapter 4</b>	<b><i>Fabrication Technologies</i></b>	<b>29</b>
<b>4.1</b>	<b>Introduction</b>	<b>29</b>
<b>4.2</b>	<b>Low stress silicon nitride</b>	<b>29</b>
4.2.1	SiN for red light	30
4.2.2	SiN for blue light	31
<b>4.3</b>	<b>Planar micro-PBS</b>	<b>33</b>
<b>4.4</b>	<b>Pop-up Micro-PBS</b>	<b>35</b>
<b>4.5</b>	<b>Summary</b>	<b>38</b>
<b>Chapter 5</b>	<b><i>Experimental Results and Discussion</i></b>	<b>39</b>
<b>5.1</b>	<b>Introduction</b>	<b>39</b>
<b>5.2</b>	<b>Measurement System</b>	<b>39</b>



<b>5.3 Fabrication results</b> .....	40
<b>5.4 Measurement results</b> .....	44
5.4.1 The PBS for DVD .....	45
5.4.2 The PBS for HD-DVD .....	50
<b>5.5 Discussion</b> .....	54
<b>5.6 Summary</b> .....	59
<b>Chapter 6 Conclusion</b> .....	60



## Figure Caption

Fig. 1.1 Schematic of the integrated optical disk pickup.....	2
Fig. 1.2 Side view of the planar optical disk pickup.....	2
Fig. 1.3 Schematic of the optical disk pickup by silicon-based stacked micro optical system.....	3
Fig. 1.4 Scheme of free-space system.....	4
Fig. 1.5 Scheme of our novel optical bench.....	7
Fig. 2.1 A thin homogenous layer of dielectric material.....	11
Fig. 2.2 A thin layer of dielectric material.....	14
Fig. 3.1 Diagram of the micro-hinge.....	19
Fig. 3.2 Schematic of the limiter.....	19
Fig. 3.3 The vertical triangular relationship of the length of the spring latches, the height of the slot, and the spacing between the spring latch and the plate.....	20
Fig. 3.4 Polarized light separation of a PBS.....	21
Fig. 3.5 Simulation of transmittance of TM mode as a function of incident angle.....	22
Fig. 3.6 Simulation of transmittance of TM mode as a function of thickness.....	23
Fig. 3.7 Simulation of reflectance of TE mode as a function of thickness.....	24
Fig. 3.8 Simulation of transmittance of TM mode as a function of incident angle.....	26
Fig. 3.9 Simulation of transmittance of TM mode as a function of thickness.....	27
Fig. 3.10 Simulation of reflectance of TE mode as a function of thickness.....	28
Fig. 4.1 Dependence of the refractive index $n$ and coefficient $k$ on the reaction gas ratio for various annealing time.....	32
Fig. 4.2 Dependence of the stress on the reaction gas ratio for various annealing time.....	33
Fig. 4.3 Flow of fabricating planar micro-PBS .....	34

Fig. 4.4 Scheme of the pop-up PBS.....	35
Fig. 4.5 Flow of fabricating pop-up micro-PBS.....	37
Fig. 5.1 The configuration of the measurement system.....	40
Fig. 5.2 Photograph of planar micro-PBS.....	42
Fig. 5.3 Scanning-electron-microscope photograph of micro-PBS.....	42
Fig. 5.4 A photograph of micro-PBS from SEM (a) Front view (b) Side view.....	43
Fig. 5.5 Photograph of micro-PBS integrated with grating and 45 ° reflectors.....	44
Fig. 5.6 Intensity ratio of TE and TM modes as a function of SiN thickness.....	46
Fig. 5.7 Beam profile caught by CCD (a) incident light (b) the light passing through PBS .....	47
Fig. 5.8 The 3-D intensity profile of the light (a) before and (b) after passing through the micro-PBS.....	48
Fig. 5.9 Cross-sectional beam profile (yz plane) of the light (a) before and (b) after passing through the micro-PBS.....	49
Fig. 5.10 Transmittance of TM mode as a function of SiN thickness.....	51
Fig. 5.11 Intensity ratio of the TE mode as a function of SiN thickness.....	51
Fig. 5.12 Beam profile of blue ray (a) incident light (b) the light passing through PBS.....	52
Fig. 5.13 The 3-D intensity profile of the blue light (a) before and (b) after passing through the micro-PBS.....	53
Fig. 5.14 Cross-sectional blue beam profile (yz plane) of the light (a) before and (b) after passing through the micro-PBS.....	54
Fig. 5.15 The SiN thin film. (a) mounted in the poly-silicon plate and (b) enlarged picture with dimples and etching holes.....	56

Fig. 5.16 The micro-PBS with curvature.....57

Fig. 5.17 Angle between the micro-PBS and the substrate.....57

Fig. 5.18 The other components integrated with the pop-up micro-PBS.....58

Fig. 5.19 The micro-PBS with modifying process (a) the front view and (b) the enlarged view.....58

Fig. 5.20 The PBS integrated with the SOI wafer.....59



## List of Tables

Tab. 1.1 Pros and Cons of four integrated optic disk pickups.....	5
Tab. 4.1 The stress of a function of annealing time.....	29
Tab. 5.1 The comparison of our micro-PBS with the results proposed by Berkeley without insertion loss.....	46

