MSTCEM
020
DU

An Investigation on Nanomanipulation Based on Atomic Force Microscope

by

Shaorong Du

Master of Science in Electromechanical Engineering

2008



Faculty of Science and Technology

University of Macau

TABLE OF CONTENTS

LIST OF FIGURES iv
LIST OF TABLES vi
LIST OF ABBREVIATIONS vii
ACKNOWLEDGEMENTS viii
DEDICATION ix
Chapter 1 Introduction 1
1.1 Nanomanipulation 1
1.1.1 Nano-science and nanomanipulation 1
1.1.2 Characteristics 2
1.1.3 Configuration 6
1.2 Atomic Force Microscope 6
1.2.1 Two kinds of design 6
1.2.2 Main components and principle 7
1.2.3 Operation modes 9
1.3 Objectives 10
1.4 Outline of the thesis 10
Chapter 2 Literature review on nanomanipulation 11
2.1 Background 11
2.2 Classification 12
2.3 AFM-based nanomanipulation 12
2.4 Related works on AFM-based nanomanipulation 14
2.4.1 Carnegie Mellon University 14
2.4.2 Michigan State University 16
2.4.3 University of Southern California 22

Chapter 3 Nanomanipulation strategy and system setup 24
3.1 CSPM4000 24
3.2 Manipulation strategy 26
3.3 System setup 29
Chapter 4 System modeling and calculations 32
4.1 Manipulator: AFM probe cantilever 32
4.1.1 Cantilever selection 32
4.1.2 Cantilever modeling 40
4.2 Modeling the nano force acting on cantilever tip 53
4.3 Nano particle and substrate 55
4.4. Calculation 56
Chapter 5 Experiments and discussion 60
5.1 Nano topography 60
5.1.1 Mica 60
5.1.2 Polycarbonate 61
5.2 Nano imprint 63
5.2.1 UM 63
5.2.2 Chinese characters of China 65
5.3 Nano pattern 68
5.4 Nano pushing 69
5.5 Discussions 71
Chapter 6 Conclusions and recommendations 73
6.1 Conclusions 73
6.2 Contribution 73
6.3 Recommendations for future work 74
BIBLIOGRAPHY 75

PUBLICATIONS 80
VITA 81